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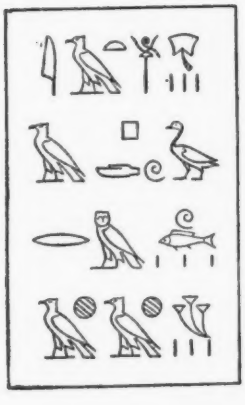

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THE JOURNAL OF WILDLIFE MANAGEMENT

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AN EVALUATION OF RESTOCKING WITH PEN-REARED BOBWHITE[1]

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To determine the value of restocking with pen-reared bobwhite, a survey of the literature and the activities of 17 important bobwhite States was made in 1948. It has become clear, after much trial and error in a number of localities, that the release of propagated pen-raised birds does not necessarily or always accomplish the desired population increases. A growing number of thoughtful administrators and sportsmen have raised questions concerning the expense of propagating bobwhite and the results obtained from game-farm birds. It is the purpose of this paper to present available information that may help to answer these questions.

The data presented here were compiled as part of long-range bobwhite research initiated by the Oklahoma Cooperative Wildlife Research Unit at the request of the Oklahoma Game and Fish Department under the direction of Director Kelly E. DeBusk. Walter P. Taylor, Leader of the Unit, and Fred M. Baumgartner, Department of Zoology, Oklahoma Agricultural and Mechanical College, have given time and supervision to the investigation and have assisted in the preparation of the present paper.

[1] Contribution from the Oklahoma Wildlife Research Unit, the Oklahoma Game and Fish Department, the Oklahoma Agricultural and Mechanical College, the Wildlife Management Institute, and the Fish and Wildlife Service, U. S. Department of the Interior, cooperating.

PREVIOUS INVESTIGATIONS

A few carefully conducted experiments have been made in Oklahoma, Missouri, Virginia, and Illinois to determine the efficacy of restocking. Taylor (1948) discusses artificial propagation in the southern States and points out that it apparently is impossible to produce sufficient numbers of bobwhite on game farms to supplement appreciably the natural production of native populations. The results show that up to this date, at least, releasing game-farm bobwhite is costly, and State game departments cannot justify the practice on an economic basis alone.

Clark (1942), reporting on a survey of restocking in 25 States, pointed out that in 1941 only 333,709 bobwhite were produced by artificial means in the entire United States at a cost of $285,615.00, or 22 per cent of the money spent on all kinds of game restocking.

One of his conclusions was that none of the States could produce reliable data on the results of restocking, although some of them were getting projects under way to obtain this information. In two successive years one State had reduced by one-half the number of birds normally released. During each of these years, accurate tabulations of the number of bobwhite killed showed that the reduction in restocking had no effect on the hunting success. A few States which questioned the effectiveness of annual restocking as a game-management measure justified their expenditures on the basis of public relations.

OKLAHOMA

In early restocking attempts hatchery bobwhite were distributed to landowners for release with the stipulation that the release area would be protected for a period of years. About 1938 a system of State refuges was established on which game-farm birds were protected. Under the Federal Aid to Wildlife Restoration program 275 refuges were added in 1940 nearly doubling the previous number (Anonymous 1941). Based on poor results obtained from the release of pen-raised bobwhite in various States, the Fish and Wildlife Service no longer approves the expenditure of federal funds for restocking. This resulted in the abandonment of the refuge system in Oklahoma. Furthermore, the Oklahoma Agricultural and Mechanical College closed its game farm in 1942.

In 1946 a cooperative plan was established between the State Game and Fish Department and sportsmen's clubs, whereby 4-week-old bobwhite are delivered to clubs (now totaling 85) for holding until release at 8 weeks of age.

In 1940 (Brill 1941a) 20,000 bobwhite were released on 275 newly established refuges. Three-fourths of the Oklahoma counties were restocked, most of them in the western part of the State. During the 1940 hunting season, only 252 bands (1.26 per cent of the released birds) were recovered. The average movement of individual birds was 2.23 miles. Lyle F. Selko, formerly in charge of quail distribution on refuges in Oklahoma, stated (Anonymous 1942) that 45 of the areas restocked in 1940 as well as nearby range were censused after the hunting season in 1941 and that only 1 per cent more birds was found on the refuges than on adjacent range. It is reported (Anonymous 1942) that 83,000 banded bobwhite were released in Oklahoma from 1940 to 1942. During the 3-year period, bands were recovered from 946 bobwhite, or 1.1 per cent of the number released. Hanson (1947) summarized the data on bobwhite restocking in Oklahoma for the period 1942–1946. He reports that 57,062 were released and that 722 recoveries (1.26 per cent of the releases) were recorded. A more optimistic report (Anonymous 1942) appeared in 1941 on the basis of a careful study in eastern Oklahoma. On two areas, each stocked with 108 bobwhite in September, a total of 119 birds was killed in November. Of those killed, 37, or 17.1 per cent of the liberations, were hatchery bobwhite; the rest were wild native birds. Another good recovery was made by the Okfuskee County Sportsmen's Club in 1947 when 300 bands (12.5 per cent) were returned from 2,389 released birds (Anonymous 1948a).

While it is admittedly true that many bands recovered by hunters are never returned to the State Game and Fish Department, the above figures have considerable significance. Even if all of the birds released in any one year were to survive, the addition to the annual harvest would be negligible. If 60,000 bobwhite were released and all were killed during the hunting season, sportsmen would bag only about 3 per cent more birds than the usual annual harvest estimated (Duck and Fletcher 1944) at some 2,000,000 bobwhite.

An outstanding investigation on survival and dispersal of game-farm bobwhite was made by Baumgartner (1944). On a study area of 3,000 acres on the Lake Carl Blackwell Project in northcentral Oklahoma, 1,064 bobwhite were liberated between 1939 and 1941. The birds were marked with aluminum leg bands, serially numbered, and also with colored celluloid bands. Part of the study area was opened to controlled hunting each year to secure band returns. Information on survival and dispersal was obtained also from sight records and spring trapping. Over the three-year period, 135 wild birds were killed. Only three bands were recovered in 1940; no bands were recovered in 1939 or 1941. Of 57 birds trapped, only 9 were banded. No banded birds were observed in the field until plantings were made in May 1940.

The Lake Carl Blackwell investigation revealed that when environmental conditions were favorable in 1940, after depletion of wild breeding stock during the fall and winter of 1939 through unfavorable weather conditions, survival of pen-reared birds was unusually high. It was estimated that as many as 50 per cent of the young-released birds furnished hunting in the late autumn of 1940, and 45 per cent were available as breeding stock the following spring. A few even survived the second summer. However, when the wild-bird population was normal, the young game-farm birds seemed unable to compete with the native stock and only a limited number survived. The released quail took up ranges within one mile of the point of liberation. Adult birds (represented by 18 per cent of the releases) liberated in the summer and autumn did not provide stock for either hunting or breeding. These observations seem to suggest the desirability of release of young pen-reared birds after the depletion of wild breeding stock.

A summary of 22,587 bobwhite liberations under the direction of the Agricultural and Mechanical College of Oklahoma from 1937 to 1940 (Baumgartner and Stonaker 1941) shows that, of 16,588 banded birds, only 0.4 per cent were reported killed by hunters. The average movement of individual birds following release was 1.45 miles; more than half of the birds took up winter ranges within 1 mile of the point of release. Records of only two banded birds with young from liberation of 74 adult males and 53 females suggest that the reproduction of these birds was extremely small. The over winter survival of only 2.3 per cent of the young-liberated birds indicates that when the population of wild birds is normal, reproduction from pen-reared bobwhite is insignificant.

While many bands were doubtlessly not reported by hunters for lack of interest or because of unwarranted fear of persecution, Baumgartner's studies

indicate an extremely high prehunting-season mortality. Apparently the majority of artificially reared birds succumb from lack of ability to adapt themselves to changes in food, temperature, moisture, the presence of natural enemies, or other conditions.

Duck and Fletcher (1944) conclude that low populations due to causes not regular in occurrence may be aided in recovery by releases of hatchery stock under good habitat conditions provided the areas are too large for restocking through natural spring shifting of wild birds. Causes of irregular low populations may be overshooting, severe local hailstorms, winter storms, droughts, and floods. Overshooting must be controlled, and low populations from this cause cannot be economically aided by release of hatchery stock year after year. It simply costs too much. Release of game-farm bobwhite is thought to be justified also as a means of encouraging habitat improvements by individual landowners. Duck and Fletcher point out that on 225 refuges in western Oklahoma 87 per cent of the refuge acreage and 85 per cent of the released stock in 1940 could be classified as unjustified. They believe that the percentage of unjustified releases would be increased with the inclusion of eastern Oklahoma. According to these authors adverse factors such as those mentioned operate more effectively in the western part than in the eastern part of the State.

ILLINOIS

One of the best-known studies of the value of artificial restocking is that of the Western Cartridge Company at East Alton, Illinois (Hart and Mitchell 1941). Investigations were made over a five-year period on a 1,200-acre tract of land where hunting was permitted. Spring releases apparently were far less effective than fall releases. From 168 banded bobwhite released in the spring of 1940 only one was recovered. During the previous year no bands were recovered from spring releases. Some success in restocking was indicated by recoveries of autumn releases. In 1940, bands from 57 (18 per cent) out of 319 birds were returned. This comparatively high percentage of return seems encouraging, although the cost per bird bagged was rather high ($3.00 to $4.00). While it may be possible for private individuals or sportsmen's clubs to restock at these costs, State game departments would find it difficult, at these rates, to provide a sufficient number of game-farm birds to supplement materially the natural production and increase the annual harvest. Thus, if the estimated 2,000,000 birds killed in one year by hunters in Oklahoma could be produced in hatcheries at these favorable Alton, Illinois rates they would cost $6,000,000 to $8,000,000!

Ralph E. Yeatter (Anonymous 1947), Game Specialist of the Illinois Natural History Survey, states that it would be necessary to expand greatly the already large number of propagated bobwhite released annually in the State to add even one bird per year to each covey reared in the wild. He also states that it is impossible on economic grounds for any State conservation department to propagate quail on the tremendous scale that would be necessary to insure good hunting each year.

MISSOURI

A carefully controlled three-year experiment by Bennitt (1944) is one of the most noteworthy contributions to

our knowledge of bobwhite restocking. Two areas, each slightly over 2,000 acres in extent, were selected for the study; one was heavily stocked with pen-reared bobwhite each spring (1942–1944) and the other served as a control area. A total of 366 healthy, banded birds were released during the three-year period. Each spring before the covey breakup and each fall before the hunting season both areas were carefully censused with dogs by staff members and students of the University of Missouri and many interested sportsmen from Columbia. Results of the investigation showed: (1) The unstocked area carried a higher population of birds, (2) the population on the stocked area was actually smaller each year in relation to the unstocked area, (3) the pen-reared quail did not supplement the natural reproduction, (4) each winter the population of the stocked area decreased to the usual carrying capacity for wild birds, and (5) no bands were recovered from the 366 banded birds although about 100 birds were killed each season on the stocked area. The study indicated clearly that if conditions are right, the birds will be there regardless of restocking. If additional carrying capacity does not exist, additional birds are wasted.

The Conservation Federation of Missouri (Anonymous 1947) recently made a survey of 15 leading quail-hunting States. Ten of these (11 including Missouri), Arkansas, Mississippi, Florida, Texas, Oklahoma, Alabama, Pennsylvania, North Carolina, Georgia, and Illinois, reported that releasing pen-reared quail did not contribute to hunting success. West Virigina reported that restocking contributes slightly, Virginia termed the effects "doubtful," and Tennessee reported that sufficient information for definite conclusions was not available for the state. Only two, South Carolina and Kentucky, replied that they considered restocking an effective measure. However, South Carolina does not release pen-raised birds, and Kentucky believes artificial replenishment helps principally in public relations. The Missouri survey prevented political pressure groups from forcing the State Conservation Commission to establish an expensive program of propagation.

VIRGINIA

The results of bobwhite restocking experiments (Phelps 1948), conducted by the Virginia Commission of Game and Inland Fisheries as a part of its Pittman-Robertson program, indicate that liberations of pen-reared bobwhite are not worthwhile. Several units, each consisting of two areas, were chosen for the study. All native bobwhite were removed in the fall from one area ("A") by shooting in the fall, and the area was stocked with banded pen-reared birds in the same number and sex ratio as those removed. One year later the birds were again removed by shooting to determine survival of banded birds and production of young. Area "B" within the unit was treated in a similar manner, except that the wild bobwhite were removed by shooting in the spring.

Unit I, area "A," consisting of 165 acres, was restocked with 29 banded bobwhite in December 1941. All birds were removed by shooting in November 1942; of the 30 bobwhite removed, only one was banded. Area "B" was restocked with 20 banded pen-raised birds in April 1942. In November

1942 no bands were recovered from the 38 quail removed from the area. In Unit II, area "A" was not treated because of loss of personnel to military service. Area "B" was restocked with 24 banded bobwhite in April 1942. None of the 19 birds removed in October 1942 was banded. A third unit was established to test the possibility of establishment of bobwhite on an area where none existed. In the spring of 1942, an area which had no quail population was stocked with 20 banded pen-reared birds. No bands were recovered from the 6 birds killed in October and November 1942. Repeated hunting for several weeks failed to reveal additional birds. Although the data are meager and the bobwhite could not be completely controlled from "drifting" in and out of the areas, the studies indicate that the carrying capacity of the land is one of the principal factors limiting the quail population.

Handley (1935) reports that of 237 captivity-reared birds released in the summer and fall of 1931, 26 per cent were retrapped (61 birds) or otherwise accounted for (3 killed by predators) after a lapse of 5–9 months. One additional bird was shot in November 1932 and 5 more were recovered by trapping in the spring of 1933, bringing the total return to 68 birds or about 29 per cent. In comparison, 245 young and adult wild-trapped bobwhite banded and released in October, November, and December 1925, showed a 38-per-cent return from shooting or retrapping during the ensuing winter. Seemingly this indicates that captivity-reared bobwhite are not handicapped in comparison to wild birds; but Handley later states that habitats will not support and hold more than appropriate numbers regardless of how many additional birds may be dumped into them.

TEXAS

In 1942, the Texas Game, Fish and Oyster Commission made an extensive survey of bobwhite restocking (Anonymous 1942, 1945) and concluded that artificial propagation could not be regarded as a sound management practice. As a result of this and other surveys, Texas has never established state bobwhite hatcheries. The administrators have felt that more bobwhite could be produced for the hunters' guns if money were spent rather for education and habitat improvements than for artificial propagation.

As an experiment, the Texas Cooperative Wildlife Research Unit purchased 52 pen-raised bobwhite from a Florida breeder and released them on excellent East Texas range in March 1936. They evidently died or moved away, for none was retaken in three years of extensive trapping. Apparently unaccustomed predation and starvation through failure to recognize native weed seeds as acceptable items of food accounted for most of the deaths.

Recently, Lehmann (1948) has been successful in transplanting "wild-trapped" bobwhite from areas of abundance to depleted areas on the King Ranch in South Texas. Birds were transplanted only to situations where populations had been decimated and natural barriers inhibited ingress. One area of approximately 20 sections that contained only two coveys in the spring of 1946 had not supported a shootable population since a hurricane in 1916. Eighty birds were released in 1946 and an additional 120 in 1947. The present popula-

tion is about 50 coveys. Under these special conditions restocking appears to bring results.

KENTUCKY

Phelps (1948) reports that a carefully supervised experiment in Kentucky showed that only 28 per cent of 360 bobwhite stocked in the fall on several areas could be located 45 to 60 days later. Only 8 per cent survived to April of the following year. Census data revealed that more birds per unit area were present on the unstocked check areas than on the restocked areas. Experiments with older bobwhite released in the spring showed that the survival success was even less than with fall-released birds; few birds could be found within several weeks after liberation.

PENNSYLVANIA

The Pennsylvania Game Commission expressed its view recently (Anonymous 1947) that releasing pen-reared bobwhite to increase populations has been unsatisfactory and that unless better results were produced, the practice of releasing such birds would be discontinued. Gerstell (1938) reported only 76 bands (0.61 per cent) returned from 12,420 bobwhite released in Pennsylvania. No estimate was made on the number of bands taken by hunters but not turned in. Restocking, according to Gerstell (1937), has probably been the least effective of the Commission's quail-management practices.

A study of propagated bobwhite and wild bobwhite under laboratory conditions (Nestler and Langenbach 1946) revealed that the oustanding difference between the wild birds and pen-reared stock was in the degree of wariness. Pen-reared birds learned quickly how to forage for wild foodstuffs. Indications from this study are that the propagated bobwhite may find difficulty in coping with natural enemies.

INDIANA

Barnes (1947) reports that a Pittman-Robertson study of 6,098 bobwhite released over a period of 3.5 years showed about 3 per cent return, or less than 1 per cent of the total hunters' kill for bobwhite in 1945. Only 2 per cent of the band returns were received after the first season, indicating a short average life span as with wild bobwhite. He states that artificial propagation is not the answer to Indiana's game-bird problem.

In a recent article, Reeves (1948) says that where food and cover conditions are so poor that wild birds cannot maintain themselves it appears foolish to expect pen-reared birds to overcome these handicaps. Yet sportsmen believe that the release of birds on areas devoid of good cover overcomes the deficiency of the site.

LOUISIANA

Analyses of returns from artificially raised bobwhite in Louisiana (Campbell *et al.* 1943) show that moderate survival was followed by low hunter success. Of birds liberated in pairs in the spring, 61 per cent raised broods averaging 13; about 30 per cent were killed by predators and accidents. Only about 3 per cent of the spring-released birds and their progeny were killed during the hunting season. Of birds liberated in groups of 10–20 in the fall, 19 out of 48 continued as covey units while 27 mingled with wild birds. All remained near the point of release.

During the hunting season 7 per cent of the fall-released birds were killed.

FLORIDA

A limited study of the comparative fall and winter survival of wild and pen-reared bobwhite was made by Frye (1942). His data indicate an approximate equality of survival between the two types of birds. Intimate contact with the birds on a 2,180-acre study area enabled Frye to record detailed histories of the coveys. For comparison of survival success, 166 pen-reared bobwhite were released in 22 check groups each of which consisted of one-half wild birds and one-half hatchery birds, all banded. At the time of final trapping (January 23–February 7), 45 wild and 48 pen-reared birds were surviving out of 83 birds of each category released between August 24 and October 25. It is suggested that releasing pen-reared birds with a few wild-trapped birds as "leaders" may be of practical application in broad-scale restocking.

Game administrators in Florida recently stated (Anonymous 1947) that pen-raised birds had been used in the past but that the percentage of survival had not been high enough to warrant expenditures for restocking.

NEW MEXICO

Ligon (1948) strongly advocates artificial aid to upland game birds in the southwest. He states that artificial propagation is mandatory where the birds must exist in scant habitats and are subject to severe winters, prolonged droughts, and heavy overgrazing. It should be emphasized that the ecological conditions found in New Mexico do not apply to the more favorable environments of the bobwhite range farther east. By the use of "adjusting units" Ligon has demonstrated that releasing pen-reared quail may be successful. More than 500 quail were liberated in 1945 and checked in 1947. Better than 90 per cent survival was obtained of pen-raised scaled, Gambel and bobwhite quails. The average numbers of young per pair raised to maturity were: Scaled quail, 8; Gambel quail, 6; and bobwhite, 10. A comparable check of 90 wild resident scaled quail showed an average of only 3 young per pair raised to maturity. The population density on the control area (about 500 acres) was more than one bird per acre at the end of the second year. Only a few scaled quail and no bobwhite or Gambel quail were present before the experiment. It is significant that releases were made where practically no quail existed; liberations in Oklahoma and other States are usually made where good populations already exist. The New Mexico Game and Fish Commission has recently embarked on an adjustment-unit program for upland game birds. Major objectives are: (1) Proper orientation of propagated stock, (2) care of resident birds in times of need, (3) insurance of survival of transplanted wild stock, and (4) expansion of ranges. It will be interesting to observe the progress in application of this new wildlife technique.

GEORGIA

In his well-known monograph on the bobwhite, Stoddard (1931) pointed out that investigations are greatly needed to determine the percentages of pen-reared bobwhite, released by different methods, that become adjusted to their environment and survive the many dangers confronting them afield. Later

(Stoddard 1936), he emphasized that environmental improvement is superior to and more economical than restocking.

MISSISSIPPI

The Mississippi Game and Fish Commission has become one of the strongest opponents of restocking with upland game birds. It has been emphatically stated (Anonymous 1946) that the money of Mississippi hunters should not be wasted on restocking and that the problem is probably mostly one of food and cover for bobwhite.

BOBWHITE STATE GAME FARM ACTIVITIES AND RESTOCKING

A current questionnaire-survey of 17 bobwhite States is summarized in Table 1. Six of the States (Alabama, Arkansas, Florida, Missouri, North Carolina, and South Carolina) have completely abandoned their bobwhite farms. Mississippi and Texas have no game farms. Indiana, Pennsylvania, and Virginia have decreased their game-farm bobwhite production. Georgia distributes bobwhite eggs to 4-H and FFA Clubs as a public-relations measure to create interest among boys and girls. Iowa and Louisiana maintain their production at 5,000 to 8,000 bobwhite per year. West Virginia increased production from 6,000 in 1947 to 9,000 (estimated) in 1948. Only Oklahoma and Kentucky reported a considerable increase in bobwhite production and at least a slight increase in the annual harvest, based on the return of bands from the pen-raised birds. Oklahoma produced about 60,000 and Kentucky 36,400 in 1948.

The survey shows that most States are in agreement that artificial restocking is not effective in augmenting either the total population or the annual harvest of bobwhite. It shows, furthermore, that with two significant exceptions (Oklahoma and Kentucky) bobwhite game farms are being abandoned and production decreased. The national trend is definitely away from restocking with pen-reared bobwhite as a means of supplying greater numbers of bobwhite for the hunter.

WHERE AND WHEN TO RESTOCK

According to Studholme (1948), game stocking is justified: (1) On areas known to meet the species requirements, but where the species has been killed out, (2) on formerly good range where the habitat was eliminated and has since developed into suitable environment, (3) on areas that lack a satisfactory native species yet provide proper habitat for a desirable non-native, and (4) on areas where the sex ratio has been so distorted that the species cannot properly reproduce. If these criteria are followed, restocking from state game farms will take its place as a minor management practice. Almost invariably pen-reared bobwhite are now released on areas where native populations already exist. Without increasing the carrying capacity of a particular area through definite habitat improvement, increases in the quail population cannot be expected. Hart and Mitchell (1947) repeatedly point out that before pen-raised birds are liberated the habitat must be improved to increase the carrying capacity of the land.

The question still remains whether birds should be liberated even on improved areas where there is a source of supply of native wild birds. The work of Murray (1948) on habitat improve-

TABLE 1. BOBWHITE GAME FARM ACTIVITIES AND RESTOCKING IN 17 STATES 1948

State	Game Farm Status	Cost/Bird Released	Comments
Alabama	Abandoned 5 years ago	$3.00	Restocking did not increase the annual harvest
Arkansas	Abandoned	—	To increase harvest, bobwhite should be released during open season
Florida	Abandoned	$1.50–2.50	High mortality in pen-raised quail and high cost made restocking worthless
Georgia	Eggs distributed to 4-H and FFA Clubs	—	Restocking was attempted for 18 years with no success. Expenditure for distribution of eggs is justified by the interest created among boys and girls
Indiana	Production decreased considerably	—	Artificial restocking is not the answer to Indiana's game-bird problems
Iowa	Production maintained at 6,000–8,000 per year	$0.68	The state has no positive evidence that bobwhite have increased because of restocking
Kentucky	Production increased considerably	$0.78	That annual harvest has been increased at least slightly is corroborated by the return of bands from the pen-raised birds
Louisiana	Production maintained at 5,000–6,000 per year	$2.00–2.50	All bobwhite are carried through winter for spring distribution. No positive evidence to indicate an increase in annual harvest, but it is believed that pen-reared bobwhite do increase the population
Mississippi	No bobwhite game farm	—	Considering the large annual harvest of quail by hunters, we do not believe that restocking with quail is necessary. There are no places in the state where there is not adequate seed stock of quail
Missouri	Abandoned	$2.00	All bobwhite farms were abandoned in the spring of 1938. Research indicates failure of restocking to augment the natural harvest. The cost per bird survived in the spring of 1938 was $32.00
North Carolina	Abandoned	—	The last year of game-farm operation was 1942. The release of game-farm-reared bobwhite did not increase the annual harvest
Oklahoma	Production increased to about 60,000 in 1948	—	Some game administrators and sportsmen feel that restocking increases both the population and annual harvest. Bobwhite are reared the last 4 weeks by 85 cooperating sportsmens' clubs
Pennsylvania	Increased production up to 1948; decreased this year	—	Populations established themselves and became fairly abundant in certain sections where bobwhite were extinct in 1936; this could have been accomplished only by restocking
South Carolina	Abandoned	—	Our native supply is sufficient to take care of our needs in most parts of the State
Texas	No game farms	—	On the basis of a survey of bobwhite restocking in other States which indicated the futility of the method, Texas never established a game farm
Virginia	Production decreased	Estimated at $3.00	Research in Virginia indicates that restocking does not increase the annual harvest
West Virginia	Production slightly increased	$3.00 for spring-released birds	Production increased from 6,000 in 1947 to 9,000 (estimated) in 1948. Brief checks on released birds have indicated very poor survival, particularly in spring-released birds

ment in Missouri indicates that native bobwhite will build up higher populations on a given area when food and cover are increased. It must also be kept in mind that soil fertility and climate set a top limit on the bobwhite population density for a given area. One cannot expect to establish a population of one bird per acre on land that is capable of supporting at its best only one bird per 10 acres. Errington (1936) has emphasized that environmental improvement, rather than restocking, is the best remedy for a quail shortage. Winter carrying capacity regulates the populations of bobwhite in the northern part of their range (probably the southern range as well) and only a certain number of birds survive in a given territory "regardless of how open the winters may be and regardless of the kinds and numbers of enemies present."

Buss, Mattison, and Kozlik (1947) have shown that on a natural, unshot bobwhite quail range in Wisconsin the normal annual turnover was 83 per cent, and that most of the mortality occurred to adults during the spring season. This indicates that pen-reared birds should be harvested heavily in the fall, that few will survive the winter, and that only an insignificant number may produce young.

When bobwhite populations are low following severe winters or poor nesting seasons, more pen-reared birds survive than during normal seasons. Baumgartner (1944) found that after the wild population had been depleted through severe winter losses fair survival of hatchery birds occurred. Similar evidence of fair survival after depletion of native stock is indicated in the comparatively high recovery (12.5 per cent) of bands from Okfuskee County, Oklahoma (Anonymous 1948a). During the 1947 nesting season, torrential rains greatly reduced the nesting success; the rainy season was followed by prolonged hot dry weather for the remaining part of the summer. Apparently these conditions were advantageous to the survival of pen-reared birds since competition from native birds was reduced.

REESTABLISHMENT OF NATIVE STOCK

Nestler and Studholme (1945) state that natural recovery of badly decimated native populations is a rather slow process and that new stock must be introduced if rapid growth of population is desired. No factual basis is given to support this contention. Hanson (1947) presents information to the contrary in his statement that severe winters like that of 1929–1930 may seriously reduce the numbers of bobwhite, but in a season or two they may be back to normal. The hunting season of 1932 is still remembered as a banner year. A population increase from one bird per 6 acres to one bird per 3 acres over a three-year period is reported by Sanders (1943). Another rapid recovery of bobwhite is shown by Errington (1945) in his fifteen-year local study of the northern bobwhite. The population was low from 1936 to 1938, but in 1939 the fall population was more than double that in the fall of 1938. In Oklahoma (Duck and Fletcher 1944) a considerable decline in bobwhite populations occurred after the severe winter of 1939–1940, yet by the fall of 1941 populations were back to normal. Duck and Fletcher do not believe that hatchery birds contribute to recovery of low native populations. Recoveries

from low population levels in northwestern Oklahoma in 1941 were equally rapid on restocked and non-restocked areas. In southwestern Texas phenomenally rapid recovery of bobwhite has been observed. Lehmann (1946) states that a pasture supporting one bird per 2 or 3 acres in the spring may have a low population the following autumn, and conversely, a ranch where quail are scarce one year often supports many the following season. In good habitats throughout most of Texas, only one good breeding season is necessary to fill the coverts to capacity from the natural increase of quail already present.

Undoubtedly the contradictory viewpoints about the rapidity of recovery in native bobwhite arise in part from conflicting evidence from the favorable southern ranges and marginal northern ranges.

ECONOMICS

Hart and Mitchell (1941) report that each hatchery bird costs only $0.77 at the time of liberation. Their band returns (25 per cent, 1939; 18 per cent, 1940), however, show that each bird bagged was worth $3.00 to $4.00. Clark (1942) reports that the average cost per hatchery quail in 1941 was $0.86 in the United States. Brill (1941b) gives an account of experience in Oklahoma in the improvement of egg production and adult quality, while at the same time the cost of production was reduced to $0.70 per bird. But at an average of 1.26 per cent in band returns over a five-year period (Hanson 1947), the cost per bird brought to bag is $55.56. The report from Okfuskee County (Anonymous 1948a) indicates that the 12.5 per cent band returns represent well over half of the bands taken by hunters. Assuming that the actual number of banded birds killed was 25 per cent of those released and that each bird was valued at $0.70 when liberated, the cost per bagged bird would be $2.80.

The success of restocking must be measured by survival to the breeding season and hunter success in the fall. The above data summarized from several states show that few birds provide breeding stock whether released in the spring or fall and that few are taken by hunters. While it may be economical to raise bobwhite, it has not been demonstrated that restocking from state game farms can be maintained on a financially sound basis. The income from license sales to quail hunters falls far short of the funds required for large-scale restocking.

FUTURE OF RESTOCKING

Gabrielson (Hart and Mitchell 1947) has pointed out that endeavors by state game departments to propagate game in great quantities for sportsmen to shoot result in bankruptcy of game funds. Losses of pen-reared birds upon release are great and the cost of raising the game is far beyond the revenue obtainable from the sportsmen. However, since the cost of producing the birds is largely a labor cost, individuals or groups of individuals who wish to perform the labor themselves or pay the cost of production can augment the supply of game available on their lands.

The Wildlife Society (Anonymous 1948b) has recently summarized the nation-wide experience of game technicians to the effect that no permanent

increase in game resources can be brought about by artificial propagation of birds and mammals. Money spent for artificial propagation often is diverted from useful enterprises, such as habitat improvement.

Steen (1948) makes a plea for facing the fact that the usefulness of artificial restocking as a tool in the public management of game is limited and rare; he points out that precious time and ground are lost in applying wrong remedies and that environmental improvement must be employed to meet the problems of today and build for the future.

While the future of restocking with pen-reared upland game birds cannot be fully predicted, definite trends are shown by Nestler (1947) in his historical compilation of game-bird propagation. Nestler states, "Undoubtedly pressure in favor of propagation of game birds for liberation will continue despite unfavorable evidence of high cost, tameness, and low survival of stock, in order to supply targets for gunners if for no better reason. However, the game-farm epoch in wildlife management, at least so far as public funds are concerned, is probably past its peak, and more attention in the future will be paid to the restoration and improvement of habitat." A further suggestion is made that the propagation of game birds in the future may be to supply the meat market rather than the open fields.

At the present time propagation for restocking purposes seems to be facing a decline, more emphasis being placed on environmental improvement as a means of increasing bobwhite populations.

SUMMARY

The present paper gives special attention to the place in bobwhite management of the method of propagation and release of pen-reared birds. A survey of the literature and policies of 17 bobwhite-quail states, summarized in Table 1, showed that the method is costly and does not materially increase the shootable population of bobwhite. With three exceptions bobwhite game farms in these states are being maintained at low level, production decreased, or abandoned.

Seemingly propagation and release of game-farm birds has a place (1) on suitable areas where the bobwhites have been killed out either by overshooting or some natural catastrophe, or (2) where favorable habitat has been created and is not being stocked by native population. Such instances will be few.

Bobwhite numbers on an area are regulated not by the birds that may be liberated but by the carrying capacity of the area during the season of greatest stress. If the habitat is improved for quail, there will be more birds. If the carrying capacity is not increased, liberation of additional birds may exercise no appreciable effect. The ability of decimated bobwhite populations to bounce back to normal in a season or two from natural increase, at least in Texas and Oklahoma, is clear.

According to our reports costs of hatchery production vary from $0.68 to $3.00. Low survival of pen-reared birds results in costs per bird in the hunter's bag from $2.80 to even $55.56 in particular cases. Apparently the income from license sales to quail hunters falls far short of the funds re-

quired for large-scale restocking.

In states already possessing large investments in quail farms, the release of pen-reared stock perhaps may be justified as a means of interesting youth groups and sportsmen's clubs.

Such farms might well be used also as production centers for game where clearly justified, on a regional basis, through sale or exchange of pen-reared stock to nearby states. The game-farm birds produced might serve also as research material, perhaps in cooperation with cooperative units or educational institutions or the United States Fish and Wildlife Service for getting answers to some of the questions sure to arise in bobwhite quail food habits, nutrition, life habits, parasites and diseases, adaptation and survival, and population dynamics.

The available evidence clearly indicates little success with large-scale restocking programs. Gabrielson (1946) points out that restocking in any form should be done only in emergencies or when high cost is not an item of consideration. He states that the birds should be released immediately before the hunting season to provide a maximum of return. At the present time, propagated birds are costly. Natural production of game is likely to be far less costly and more practical.

LITERATURE CITED

Anonymous. 1941. Statewide bobwhite quail management and restocking project, No. 4-D. Pittman-Robertson Report, Oklahoma Game and Fish Commission. 10 pp.

———. 1942. The propriety of attempting to restore bobwhite quail in Texas by raising the quail in pens for release in the wild. Texas Game, Fish and Oyster Commission. Mimeographed. 14 pp.

———. 1945. Why Texas doesn't pen-raise quail. Texas Game and Fish, **3**: 6, 16.

———. 1946. Why not pen-raised quail for restocking? Mississippi Game and Fish, **10**: 3.

———. 1947. The Missouri conservation program approval and disapproval. Conservation Federation of Missouri. Webster Groves, Missouri. 30 pp.

———. 1948a. Okfuskee County Sportsmen's Club proves best cooperator in quail leg-band recoveries. Oklahoma Game and Fish News, **4**: 9.

———. 1948b. Report of the joint committee on wildlife. The Wildlife Society and the Division of Biology and Agriculture, National Research Council. The Wildlife Society Newsletter, Winter Issue, 1948.

BARNES, WILLIAM B. 1947. Is artificial propagation the answer? Outdoor Indiana, **14**: 8–10.

BAUMGARTNER, F. M. and R. S. STONAKER. 1941. An evaluation of the artificial propagation of bobwhite quail at the Lake Carl Blackwell Game Farm. Manuscript. 9 pp.

BAUMGARTNER, F. M. 1944. Dispersal and survival of game farm bobwhite quail in northcentral Oklahoma. Jour. Wildl. Mgt., **8**: 112–118.

BENNITT, RUDOLF. 1946. Report on a three year quail stocking experiment. Missouri Conservationist, **7**: 10–11.

BRILL, CHARLES J. 1941a. Pen-raised versus wild-reared. Southern Sportsman, pp. 24–25.

———. 1941b. Down comes the cost of quail production. Southern Sportsman, **5**: 9, 19.

BUSS, IRVEN., HELMER MATTISON, and FRANK M. KOZLIK. 1947. The bobwhite quail in Dunn County, Wisconsin. Wis. Conservation Bulletin, **12**(7): 6–13.

CAMPBELL, JOHN S., GEORGE H. PENN, JR., H. EUGENE WALLACE, and M. GEORGE GREIG, JR. 1943. Analyses of reported returns from artificially raised bobwhites in 1941. Louisiana Acad. Sci., **7**: 38–43.

CLARK, ARTHUR L. 1942. Annual restocking—game management or public relations? Trans. N. Amer. Wildlife Conf., **7**: 179–184.

DUCK, L. G. and JACK B. FLETCHER. 1944. A survey of the game and fur-bearing animals of Oklahoma. Oklahoma Game and Fish Commission. Pittman-Robertson Series No. II, State Bul. 3, 144 pp.

ERRINGTON, PAUL L. 1936. Restocking quail in our northern States. Minnesota Conservationist Sept.–Oct., pp. 1–11, 15.

———. 1945. Some contributions of a fifteen-year local study of the northern bobwhite to a knowledge of population phenomena. Ecol. Mono., **15**: 1–34.

FRYE, O. EARLE, JR. 1942. The comparative survival of wild and pen-reared bobwhite in the field. Trans. N. Amer. Wildlife Conf., **7**: 168–175.

GABRIELSON, IRA N. 1946. Changing concepts of wildlife management. Missouri Conservationist, **7**: 3–5, 12.

GERSTELL, RICHARD. 1937. Practical management of the bobwhite quail on the northern range. Penn. Game News, **8**: 10–11, 28–29.

———. 1938. An analysis of the reported returns obtained from the release of 30,000 artificially propagated ring-neck pheasants and bobwhite quail. Trans. N. Amer. Wildlife Conf., **3**: 724–729.

HANDLEY, CHARLES O. 1935. The survival of liberated bobwhite quail. Trans. Amer. Game Conf., **21**: 377–380.

HANSON, H. GORDON. 1947. Missing—56,340 bobwhites! Oklahoma Game and Fish News, **3**: 20.

HART, DENNIS and TED MITCHELL. 1941. Report of data and indications as of spring 1941 relative to the value of artificial stocking. Game Restoration Dept., Western Cartridge Co., East Alton, Ill. 12 pp.

LEHMANN, VALGENE W. 1946. Bobwhite quail reproduction in southwestern Texas. Jour. Wildl. Mgt., **10**: 111–123.

———. 1948. Restocking on King Ranch. Trans. N. Amer. Wildlife Conf., **13**: 236–239.

LIGON, J. STOKLEY. 1948. Unit administration for upland game birds. Oklahoma Game and Fish News, **4**: 6–7.

MURRAY, ROBERT W. 1948. Wintering bobwhite in Boone County, Missouri. Jour. Wildl. Mgt., **12**: 37–45.

NESTLER, RALPH B. and ALLAN T. STUDHOLME. 1945. The future of pen-reared quail in post-war restocking programs. Penn. Game News, **16**: 3, 26–27, 30.

NESTLER, RALPH B. and JOHN R. LANGENBACH. 1946. Propagated quail versus wild quail as studied under laboratory conditions. Penn. Game News, **16**: 6–7, 22–23.

NESTLER, RALPH B. 1947. Game bird propagation—its beginning, growth, and future. Penn. Game News, **18**: 10–11, 30–33, 36, 40.

PHELPS, CHESTER F. 1948. Some results of quail restocking experiments in Virginia and neighboring States. Virginia Wildlife, **9**: 4 pp.

POUGH, RICHARD H. 1948. The arguments against the annual stocking of already inhabited coverts with artificially reared game birds. Trans. N. Amer. Wildlife Conf., **13**: 228–235.

REEVES, M. C. 1948. Tractor vs. quail. Outdoor Indiana, **15**: 14–15.

SANDERS, EARL. 1943. Development of a bobwhite management area in southern Iowa. Iowa Agric. Expt. Sta. Res. Bul., **317**: 699–726.

STEEN, MELVIN O. 1948. Shall we improve habitat or stock—for wildlife? Outdoor America, **13**: 4, 10.

STODDARD, HERBERT L. 1931. The bobwhite quail: its habits, preservation and increase. Charles Scribner's Sons. 559 pp.

———. 1936. Bobwhite quail and their preferred cover. Outdoor Florida, **1**: 11–12.

STUDHOLME, ALLAN T. 1948. A bird in the bush is worth two in the hand. Trans. N. Amer. Wildlife Conf., **13**: 207–214.

TAYLOR, WALTER P. 1948. Land wildlife resources of the south. Manuscript, 102 pp.

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MIGRATION TENDENCIES OF THE EASTERN MOURNING DOVE IN NORTHERN INDIANA[1]

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The mourning dove in Indiana has been protected since early in 1900 and possibly for this reason no detailed study has been made of this species in the state. A Pittman-Robertson study of the ring-necked pheasant throughout its range in northern Indiana, involved considerable driving during which time daily records were maintained of doves observed throughout the year. In addition, a September pheasant roadside count conducted for eight consecutive years has included a tabulation of doves seen along the routes. The two methods are discussed separately, since the first involves all-day observations and the second only a short period after sunrise. The northern one-third of Indiana was covered by these observations.

As recent interest has been aroused relative to correlating dove population trends in the north with region-wide studies in the southeast, these findings in Indiana may be of value.

Daily Roadside Observations

Dove observations, while traveling about the northern portion of the state, were started in January 1942, but were interrupted for a period by the war. Studies were again initiated in September, 1945, and carried on until June of 1947. This break, however, is of little importance, since the monthly observations were averaged to gain the information needed. Observations covered a 30 months' period and involved 5,266 doves seen in 23,329 miles traveled over all types of roads, but at a fairly consistent speed. No specific routes were followed.

The dove population in northern Indiana increases considerably from winter to summer. On a monthly basis, it was found that the influx of doves begins in April (Figure 1). The population rise, resulting from spring and early summer broods along with early migrants, reaches a climax in August. Flocking and southern movement is noted during September; however, October brings the sudden departure of all but a few resident birds. The reason for the lower average counts in November and December, as compared with January and February, is not known. It would appear that these four months should remain approximately the same until the spring influx begins. One supposition is that there may be a local southward movement from northern Indiana during November and December to escape severe weather. Another is that the figures presented during these two months actually represent the true winter population and the larger number in January might be an influx of doves from farther north. Whatever the reasons may be, the aver-

[1] Appreciation is expressed to Wm. B. Barnes, Indiana Department of Conservation; Harold S. Peters, Fish and Wildlife Service; and Leonard E. Foote, Wildlife Management Institute, for their helpful advice and suggestions.

ages for the fall and winter months, as previously shown, however, are approximately the same.

For a period of 23 months, the daily observations were divided into three periods: morning, up to 10 o'clock; midday, 10 to 3 o'clock; and evening, after 3 o'clock. It was found that throughout the year the average morning observation was 29.6 doves per 100 miles. This dropped to 12.8 during the midday period, and then rose to 24.2 in the evening (Table 1). On a monthly basis, however, there is considerable variation in the periods when most birds were seen. This was undoubtedly influenced by some small samples and the particular section in which the sample was taken. The upsurge during the evening period in September was the result of 3 flocks of 60, 10, and 40 being seen over a 12 mile stretch in 1942. Whether or not these fluctuations between the periods are

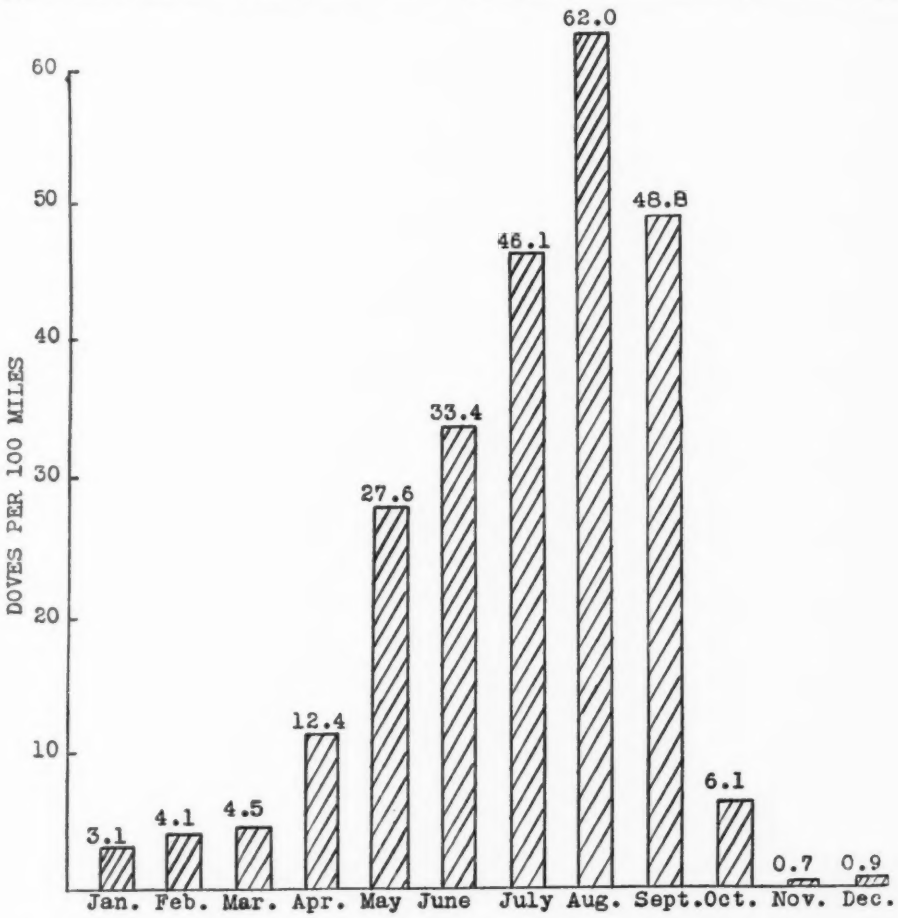

FIG. 1. Average number of doves per 100 miles traveled, by months, during 30 months of observations in northern Indiana between 1942 and 1948.

TABLE 1. AVERAGE NUMBER OF DOVES PER 100 MILES TRAVELED, BY MONTHS AND PERIOD OF DAY, DURING 23 MONTHS OF OBSERVATIONS IN NORTHERN INDIANA BETWEEN 1942–1948

Month	Morning			Midday			Evening		
	Miles	Doves	Doves per 100 Miles	Miles	Doves	Doves per 100 Miles	Miles	Doves	Doves per 100 Miles
January	607	21	3.5	1,209	53	4.4	569	0	0.0
February	556	11	2.0	674	19	2.8	678	19	2.8
March	370	37	10.0	263	2	0.8	166	15	9.0
April	317	47	14.8	657	45	6.8	403	50	12.4
May	170	45	26.5	298	37	12.4	193	65	33.7
June	269	64	23.8	254	21	8.3	86	8	9.3
July	280	137	48.9	535	124	23.2	402	93	23.1
August	673	624	92.7	1,045	442	42.3	903	558	61.8
September	781	366	46.9	482	129	26.8	103	172	167.0
October	431	50	11.6	727	26	3.6	223	8	3.6
November	165	1	0.6	545	5	0.9	156	0	0.0
December	137	5	3.6	362	1	0.3	195	0	0.0
Totals	4,756	1,408	29.6	7,051	904	12.8	4,077	988	24.2

significant will have to be determined when further data are available.

In addition to the data collected on relative abundance and period of observations, information was also gathered on flocking, but only over a period of 20 months. These data proved puzzling from the standpoint of the disappearance of the large number of small groups without the apparent formation of very many large flocks, at least within northern Indiana, especially the northeast (Table 2). Migratory tendencies are shown in the formation of larger groups in August. The formation of flocks seems to gain momentum for the south-

TABLE 2. NUMBER AND SIZE OF DOVE FLOCKS, BY MONTHS, DURING 20 MONTHS OF OBSERVATIONS IN NORTHERN INDIANA BETWEEN OCTOBER 1, 1945 AND MAY 31, 1947

Month	Flock Sizes											
	1	2	3	4	5	6	7	8	9–18	19–28	29–38	39& Over
January	4			2					2		1	
February	6	1	1						3			
March	13	5	3				2	1				
April	57	31	4						1			
May	50	29	7	3		1						
June	46	13	4	1	1							
July	98	62	14	10	3	2	1	2				
August	241	101	29	36	11	3	4	1	11	1	2	2
September	7	5	3	1			2		1			
October	7	3		1								
November	3		1									
December	1				1							
Totals	533	250	66	54	16	6	9	4	18	1	3	2

ern flight in August with flocks of from 9 to 18 birds predominating. It is interesting to note the sudden disappearance of the large number of small groups in September, without the observation of a large number of flocks. This may mean that the large number of singles and pairs noted in August are juveniles and that they move southward at random in small groups. The adults may then follow at a later date.

SEPTEMBER ROADSIDE COUNT

As has been pointed out, the northern Indiana population peak is reached in August. This is followed by a slight drop in September when the doves start moving south. It is during this month that a pheasant roadside count is conducted in northern Indiana. Miscellaneous observations include the number of doves seen. This information has been collected, for the most part, over the same routes since 1942; consequently, it gives a fairly good picture of the September dove status for the northern portion of the state (Figure 2). The number of doves seen per 100 miles was above 170 for the first three years of the survey, followed by a low of 113 in 1945. A decided increase occurred in 1946, when 195 doves were seen per 100 miles, after which there was a steady decline during the next two years. The 1949 count of 229 doves per 100 miles was the highest on record.

The theory has been presented that annual variations in the periods of migration caused these fluctuations rather than population trends. Possibly this is so, but there is no evidence to substantiate the belief. There is definitely no correlation between the fluctuations and the mean or minimum temperatures during August or September.

A point of interest, derived from the 1946 and 1947 roadside counts, was the location of doves in relation to telephone and power lines. The classification was based upon the presence or absence of wires along or close to the road at the point of the dove observation. It was found during the two counts that 91.9 per cent of all doves observed were close to or on lines which occurred, on the average, along 75.5 per cent of each route. In 1946, there were 240 doves seen per 100 miles of lines as compared to 60 where lines were absent. In 1947, 190 were observed for every 100 miles of line and again only 60 where lines were absent. This

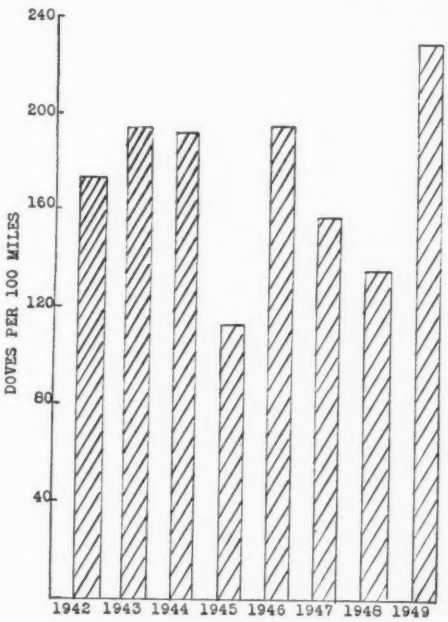

FIG. 2. Number of doves observed per 100 miles, by years, as determined by the September pheasant roadside count in northern Indiana, 1942–1949.

definitely establishes a loafing preference for power and telephone lines and is a very important census factor in those regions where lines are accessible to roads.

SUMMARY

Daily roadside observations in northern Indiana, involving the eastern mourning dove, were made during a 30 months' period. A total of 5,266 doves were observed during 23,329 miles driven.

In northern Indiana, the influx of migrants begins in April and the population rise reaches a peak in August.

Southern migration starts in September, followed by a sudden withdrawal of all but the resident stock in October.

Many of the small groups appear to leave without forming large flocks. Of those flocks observed, the smaller one, 9–18, predominated. Most of them were observed in August.

Information collected over a period of eight years during the September pheasant roadside counts showed the lowest relative abundance of 113 doves per 100 miles traveled in 1945. It was again normal in 1946 with 195 per 100 miles, declined for the next two years, and increased to 229 in 1949.

A special check in 1946 and 1947 definitely established the fact that doves like to loaf on power and telephone lines, which is an important census factor. Slightly more than 90 per cent of the observations were close to or on these lines and there were 3 to 4 times as many doves seen per 100 miles of road as there were where lines were absent.

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CONDITION OF THE MANDIBULAR TEETH OF A SIXTEEN AND A HALF YEAR OLD WHITE-TAILED DEER*

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This note is a supplement to a paper by Severinghaus (1949). The oldest deer available at that time was 10½ years old. Since then the skull and lower jaw of a female white-tail (*Odocoileus virginianus*) 16½ years old have been added to the collection.

She was picked up as a fawn and throughout her life lived in Warren County, New York, about five miles northwest of Knowlhurst. Mr. and Mrs. Earl Osterhout took care of her. She was allowed to roam the woods during the year, except for a period of about two mon'hs (before, during and after the deer season). During ten months of the year she lived largely on natural foods but had access to hay and ground horse- or cow-feed. During her confinement each year she ate hay, grain and

* A contribution from Pittman-Robertson Wildlife Restoration Project 28-R, New York State Conservation Department, Bureau of Fish and Wildlife Investigations.

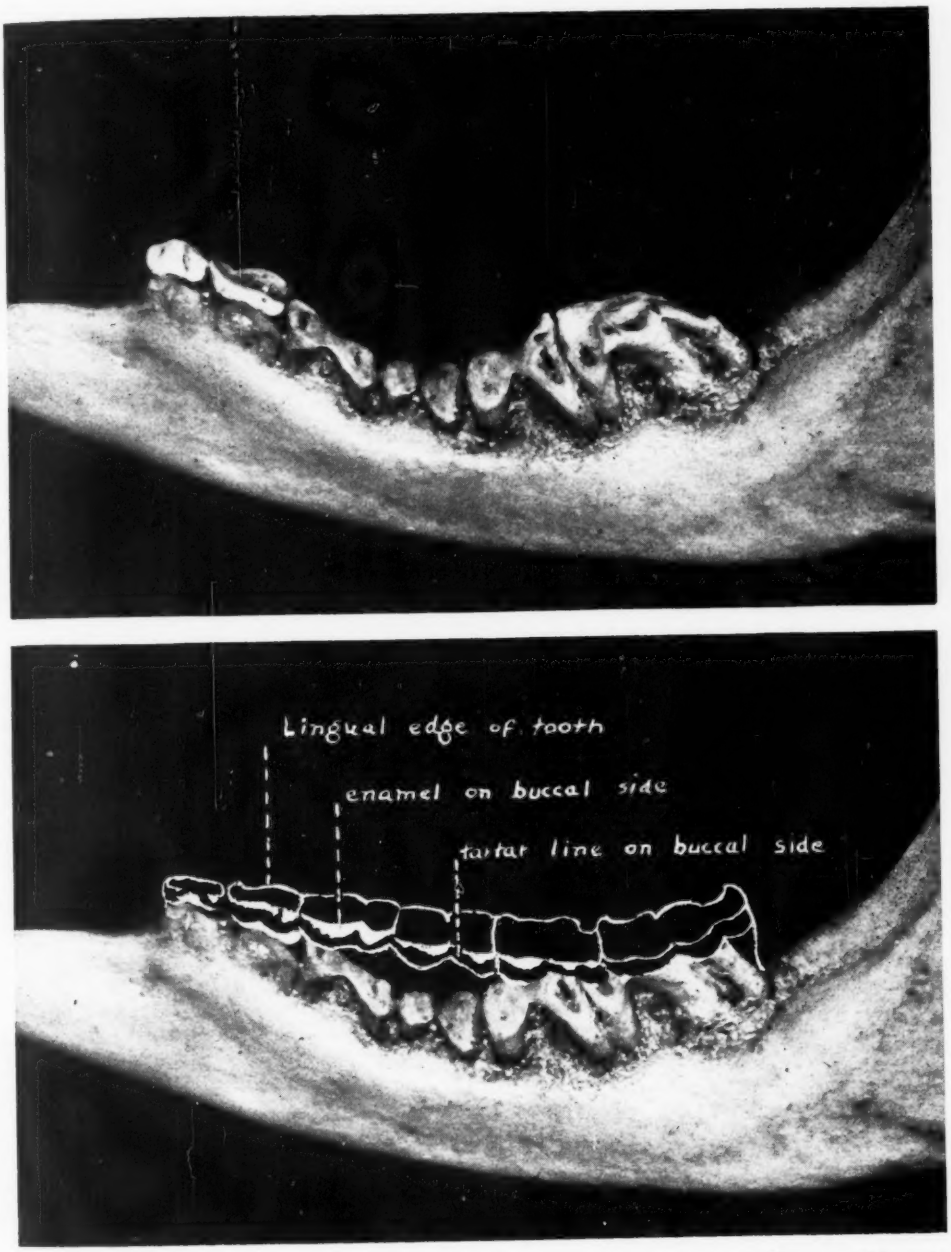

PLATE 10. A, Condition of teeth of white-tailed deer sixteen and a half years old; note uneven wear. B, Photo A with a typical ten and a half year old set of teeth drawn over them so as to illustrate amount of wear that has taken place during the six year period. Natural size.

ground feed. On a warm sunny afternoon in mid-September she died of old age in the side yard while she was asleep. Her carcass was exhumed the following May and it was necessary to sift the soil in order to find her teeth. After the jaw and skull were cleaned, Mr. Louis J. Koster, Senior Museum Technician, State Education Department, Albany cemented the teeth in place. The photographs were taken by Earl J. McGuirk, and Nicholas Drahos sketched the tooth condition of the 10½-year-old in the composite picture. Both men are employees of the New York State Conservation Department.

CONDITION OF THE TEETH

The wear on the mandibular teeth of this deer was not uniform (Plate 10, A). The first premolars showed practically no wear (their maxillary opposites apparently had been missing for about half her life; therefore, little wear occurred). The second premolars showed wear equal to that of a normal 10½-year-old deer. The necks of the third premolars were practically worn away—only about half a millimeter of the neck connected the anterior and posterior roots. The necks of the first molars were completely worn away, the roots were no longer connected by the neck and one or two millimeters of the roots were worn away. The second molar of the right mandible showed more wear than the companion tooth of the left side. On the right side the neck was completely worn away and about one millimeter of the roots was gone, while on the left side about half a millimeter of the neck joined the roots. The third molars were heavily worn (the left and right teeth showing about equal wear) but the buccal side of each tooth was much more heavily worn than the lingual side.

In order for this amount of wear to take place, the jaw bones from the middle of the third premolars to the middle of the third molars had actually been dissolved away (osteolysis) in order to expose the roots of the teeth. Judging from the jaws of other deer, about five to seven millimeters of jaw bone had actually been lost by this process.

How much wear took place on the teeth between 10½ and 16½ years is shown, approximately, in Plate 10, B. This plate shows the 16½-year-old teeth with the occlusal surface, buccal enamel and buccal tartar line of a typical 10½-year-old set of teeth drawn over them. This illustration was made by projecting the picture of the 10½-year-old (Plate 7, D; specimen number P-121; Severinghaus 1949) on the 16½-year-old picture and drawing in the outline of the 10½-year-old teeth. This was done with both pictures at natural size as they are in Plate 10, A and B.

From this composite picture the differences between the lingual edges of the two specimens and the buccal edges were measured. The results of these measurements are shown in Table 1.

This table shows approximately how much tooth has worn away between 10½ and 16½ years. This, of course, depends upon the accuracy of the assumption that the 10½-year-old specimen represents the condition of the 16½-year-old at the time she was 10½ years old. Accepting this assumption, an average of about 5.8 millimeters of tooth wore away in six years. As stated earlier, the wear was not uniform and

TABLE 1. DISTANCE IN MILLIMETERS THAT THE OCCLUSAL SURFACES OF THE MANDIBULAR TEETH OF THE 16½-YEAR-OLD WHITE-TAILED DEER DEPARTED FROM THOSE OF A TYPICAL 10½-YEAR-OLD SPECIMEN

Side of Teeth	Premolars*				Molars†							Average
	1	2	3 Ant.	3 Post.	1 Ant.	1 Post.	2 Ant.	2 Post.	3 Ant.	3 Mid.	3 Post.	
Lingual	+3.0	0.0	−5.8	−11.6	−11.5	−11.0	− 8.8	− 5.0	−0.3	−0.3	−3.7	−5.0
Buccal	+3.0	0.0	−5.8	−12.1	−10.7	−13.3	−11.3	−11.0	−5.6	−3.6	−2.5	−6.6
Average	+3.0	0.0	−5.8	−11.85	−11.4	−12.15	−10.05	−8.0	−2.85	−1.95	−3.1	−5.8

* Premolars 1 and 2 are single crested teeth, therefore only one measurement. Premolar 3 has four distinct crests, each of which was measured.

† Molars 1 and 2 have four crests, each of which was measured. Molar 3 has four crests and a distinct posterior crest so as to allow for six measurements.

the individual measurements in the table show how irregular the wear actually was. The specimen is probably atypical, but lacking anything better, it will help to estimate the age of the rare deer that live beyond ten or eleven years of age.

LITERATURE CITED

SEVERINGHAUS, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Jour. Wildl. Mgt., 13(2): 195–216.

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SEX RATIOS AND AGE CLASSES OF MAINE MUSKRATS[1]

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A study was made of the common muskrat (*Ondatra zibethica zibethica*) from 1945 to 1948 by the writer for the Maine Cooperative Wildlife Research Unit. During this investigation sex and age data were obtained on 5,429 muskrats from central and eastern Maine. Of these animals, 5,037 were taken by means of steel traps and 392 were young of litters examined at the houses. It is assumed that the trapping pressure would be the same on both sexes and all age classes and the data are being presented on that basis.

During the litter study sex data were secured on 392 young muskrats ranging from 2 to about 28 days in age. They were sexed in the manner described by Dozier (1942). Mammae were evident on the youngest females examined. They were of value in helping to determine the sex of the young until the

[1] Contribution from the Maine Cooperative Wildlife Research Unit—Maine Department of Inland Fisheries and Game, University of Maine, Wildlife Management Institute, and the U. S. Fish and Wildlife Service, cooperating. Howard L. Mendall supervised the project and gave valuable assistance in the preparation of the manuscript. Malcolm W. Coulter, James R. Reilly, Howard E. Spencer, Jr., and Bertrand E. Smith helped in many ways in the procurement of field data. Special thanks are due many trappers and fur dealers for their fine assistance and cooperation.

age when their bellies became too heavily furred.

During fall and early winter (mostly November), 951 animals and pelts were examined. They were sexed in the manner described by Buss (1941) and by Dozier (1942). On unskinned muskrats the presence or absence of a penis was used for sex determination. On pelts the presence or absence of mammae was used. These data were further broken down into subadult (young of the year) and adult (over one year old) age groups. This was done by the method described by Applegate and Predmore (1947). Briefly, this is the presence of a striped primeness pattern on subadult pelts and a spotted pattern on the adult pelts. This method was checked against a number of animals aged by internal examination of sex organs and proved to be reasonably accurate.

Additional sex data were secured on 3,676 spring- (April and May) trapped muskrats. These animals were sexed in the same manner as the fall sample. All spring-trapped muskrats were considered to be adults—so far as is known there is no accurate method to age these animals. Measurements were taken of many reproductive organs to see if they might be used as age indicators; however, many of them were sexually active thereby invalidating this method.

SEX RATIOS

Sex Ratios by Seasons and by Ages.—The data compiled by seasons and by ages for the period of the study are presented in Table 1.

From the table it can be noted that of the 392 young (from 2 to about 28 days old) examined at the houses, 59.4 per cent were males giving a sex ratio of 146 males:100 females. This is somewhat more males than Errington (1939) reported. In a sample of 878 young less than two weeks of age he found 54.4 per cent males. This difference of 5 per cent could be due to the smaller sample from Maine.

TABLE 1.—MUSKRAT SEX RATIOS IN MAINE BY SEASONS AND BY AGES

Period	Age	Number		Total	Sex Ratio Male:Female
		Male	Female		
Summer (May–August)	Young	233	159	392	146:100
Fall (Mostly November)	Subadults	402	279	681	144:100
	Adults	150	120	270	125:100
	All Ages	552	399	951	139:100
Spring (April–May)	Adults	2,038	1,638	3,676	124:100

Fifty-nine per cent of 681 November trapped subadult muskrats were classified as males, as were 55.5 per cent of 270 adults. The sex ratio of the all-aged group of 951 individuals in Maine was 58.1 per cent males. The fall sex ratio of the Maine muskrats is approximately midway between those reported for Iowa by Errington (1940) and Wisconsin by Buss (1941).

The spring sample of 3,676 muskrats (Table 1) was 55.4 per cent males, giving a sex ratio of 124 males:100 females. A comparison of these data with those of other investigators show them to be

very similar to figures for New York (Dozier 1945) and Ohio (Anderson 1947) and reasonably so for Minnesota (Hatfield 1939). However, the Vermont findings of Seamans (1941) reveal 10 per cent more males.

These sex data reveal that there was only a slight decrease in the percentage of males in the Maine population from the age of a month or less until autumn. From fall until the following spring the losses suffered by the males were disproportionate amounting to 15 for every 100 females. From spring to fall the mortality was nearly equal on the adults of both sexes.

Sex Ratios of Young Muskrats by Monthly Periods.—During the litter study the impression was gained that the percentage of females in the litters increased from spring until fall (Table 2). There were nearly twice as many males as females found in May litters. This spread decreased during June and July until in August a small sample revealed more females than males. The sample is too small to establish this trend definitely but it does strongly suggest a decrease in the percentage of males as the breeding season progresses. As was previously noted the sex ratio of all young examined disclosed a preponderance of males amounting to 146 males:100 females.

Spring Muskrat Sex Ratios by Weekly Trapping Periods.—Several references are made in the literature to the effect that toward the end of the spring muskrat trapping season the percentage of females in the catch tends to increase. No Maine trapper was ever heard to express such an opinion. However, if there were a point in the trapping season where females increased in the catch, knowledge of such a fact would be a very good tool of management. In order to check on this problem, data were compiled by weekly periods for those places where trapping was continuous, or nearly so, for most of the trapping season. Too few muskrats were examined the last two weeks of the season (April 28–May 11) to be of significance and they are not being considered herein. These data are given in Table 3.

It can be noted that there was a preponderance of males in the sample at all times and that the tendency was for this percentage to rise as the trapping season progressed. Seamans (1941) presented data from Vermont on this point and also concluded that his material did not support the contention that there was an increase in females toward the end of the season. Dozier (1945) in writing of his investigations at the Montezuma National Wildlife

TABLE 2.—SEX RATIO OF MAINE MUSKRAT LITTERS BY MONTHLY PERIODS

Month	Number		Total	Sex Ratio Male:Female
	Male	Female		
May	83	42	125	198:100
June	88	60	148	147:100
July	51	44	95	116:100
August	11	13	24	85:100
Total	233	159	392	146:100

TABLE 3.—SPRING MUSKRAT SEX RATIOS IN MAINE BY WEEKLY TRAPPING PERIODS

Period	Number		Total	Per Cent		Sex Ratio Male:Female
	Male	Female		Male	Female	
April 1–6	283	217	500	56.6	43.4	130:100
April 7–13	220	190	410	53.7	46.3	116:100
April 14–20	104	73	177	58.8	41.2	143:100
April 21–27	51	21	72	70.8	29.2	242:100
Total	658	501	1,159	56.8	43.2	131:100

Refuge in New York, states, "The preponderance of males was highly significant; and was maintained throughout the trapping operations. This tends to confirm findings (Dozier 1944) for *Ondatra z. macrodon* on the Blackwater Refuge in Maryland which are in disagreement with the common belief of trappers that more females than males are taken the last few weeks of the trapping season." In Utah, Marshall (1937) reported on 491 spring-trapped muskrats. His data also reveal no increase in the female percentage toward the end of the season. Thus, it seems that at least in the Northeast and East and some places in the West a preponderance of male muskrats exists in the population throughout the spring trapping season.

AGE RATIOS

The high reproductive potential of muskrats has long been recognized. This has led to the widespread assumption that the fall population will invariably be high. Little consideration has been given to the losses which might attend such high reproductive ability thereby reducing the increase.

From Table 1 it can be noted that data from 951 November-trapped muskrats were divided into subadult and adult age classes. These classes were further subdivided into male and female groups. Of all individuals examined, 681 (71.6 per cent) were classed as subadults and 270 (28.4 per cent) as adults. The subadults contained 402 (59.0 per cent) males and 279 (41.0 per cent) females, while the adults consisted of 150 (55.5 per cent) males and 120 (44.5 per cent) females. Thus, it may be seen that there were 120 adult females to 681 subadults or an average of about 5.7 young for each adult female

TABLE 4.—PERCENTAGE OF SUBADULTS AND ADULTS IN FALL MUSKRAT POPULATIONS (Data from the Literature)

Authority	Locality	Period	Per Cent		Total Number
			Sub-Adults	Adults	
McCann (1944)	Minnesota	Fall	72.6	27.4	564
Baumgartner and Bellrose (1943)	Illinois	November 15–January 15	71.1	28.9	1,147
Baumgartner and Bellrose (1943)	Michigan	November 1–January 31	64.7	35.3	7,511
Applegate and Predmore (1947)	Michigan	October–December	79.7	20.3	64

in the fall which is not an exceedingly high rate of increase. A comparison of these findings can be made with other investigators in Table 4. In summing up their findings Baumgartner and Bellrose (1943) state, "Assuming that trapping directly reflects population ratios, the average pair of adult muskrats produced only 4 to 5 harvestable muskrats during the 1940 breeding season." McCann (1944) reported that in Minnesota he found 4.8 young to each adult female in the fall. Errington (1941) in writing of the Iowa muskrat suggests a November age ratio of 1 breeding female to 10 subadults on small woodland or pasture watercourses and 1 breeding female to 19 subadults from small watercourses bordered by cornfields. Thus, it can be seen there is quite a difference in the age ratios reported for Iowa as against Illinois, Michigan, and Minnesota. The Maine, Illinois-Michigan, and Minnesota findings are somewhat comparable.

SUMMARY

1. Sex and age data were secured on 5,429 Maine muskrats from 1945 to 1948. The spring and summer ratio of young was 146 males:100 females. By fall the subadults had a ratio of 144 males:100 females, the adults had a ratio of 125 males:100 females, while both groups combined gave a ratio of 139 males:100 females. The spring sex ratio was found to be 124 males:100 females. This would suggest a disproportionate mortality of males during the winter and spring periods. The sex ratio of muskrat litters was largely male during the early part of the reproductive season but as the season progressed the spread tended to decrease. During the spring trapping season the males were found to outnumber the females at all times.

2. Of 951 fall (mostly November) muskrats, 681 (71.6 per cent) were subadults and 270 (28.4 per cent) were adults. One hundred and twenty of the adults were females—this gave an average of 5.7 young for each female. This rate of increase is not nearly so large as is often believed.

LITERATURE CITED

ANDERSON, JOHN M. 1947. Sex ratio and weights of southwestern Lake Erie muskrats. Journ. Mam., **28**: 391–395.

APPLEGATE, VERNON C. and HENRY E. PREDMORE, JR. 1947. Age classes and patterns of primeness in a fall collection of muskrat pelts. Jour. Wildl. Mgt., **11**: 324–330.

BAUMGARTNER, LUTHER L. and FRANK C. BELLROSE. 1943. Determination of sex and age in muskrats. Jour. Wildl. Mgt., **7**: 77–81.

BUSS, IRVEN O. 1941. Sex ratios and weights of muskrats (*Ondatra zibethica zibethica*) from Wisconsin. Journ. Mam., **22**: 403–406.

DOZIER, HERBERT L. 1942. Identification of sex in live muskrats. Jour. Wildl. Mgt., **6**: 292–293.

———. 1944. Color, sex ratios, and weights of Maryland muskrats, II. Jour. Wildl. Mgt., **8**: 165–169.

———. 1945. Sex ratio and weights of muskrats from the Montezuma Wildlife Refuge. Jour. Wildl. Mgt., **9**: 232–237.

ERRINGTON, PAUL L. 1939. Observations on young muskrats in Iowa. Journ. Mam., **20**: 465–478.

———. 1940. Natural restocking of muskrat-vacant habitats. Jour. Wildl. Mgt., **4**: 173–185.

———. 1941. Versatility in feeding and population maintenance of the muskrat. Jour. Wildl. Mgt., **5**: 68–89.

HATFIELD, DONALD M. 1939. Notes on sex ratio in Minnesota muskrats. Journ. Mam., **20**: 258.

MARSHALL, WILLIAM H. 1937. Muskrat sex-ratios in Utah. Journ. Mam., **18**: 518–519.

McCANN, LESTER J. 1944. Notes on growth, sex, and age ratios, and suggested management of Minnesota muskrats. Journ. Mam., **25**: 59–63.

SEAMANS, ROGER. 1941. Lake Champlain fur survey. Vermont Fish and Game, Bull. 3–4.

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METHODS OF MEASURING PRODUCTIVITY IN RACCOONS[1]

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INTRODUCTION

The raccoon is a species in which any attempt to determine the absolute numbers present in an area as large as a state is utterly impracticable. When complete fur records are available they are unsatisfactory, because of the low value of the raccoon pelts prevailing. Many hunters skin the animal for its flesh and leave the nearly worthless pelt in the woods.

Thus indices of abundance and productivity are needed if raccoons are to be fully studied and managed. These indices may be sought in the sex and age composition of the harvest as well as in the number of young produced per adult female, for Leopold (1933: 139) has pointed out that management involves more than mere enumeration; the composition and condition of the stock is often quite as important as its numbers. Before these indices could be made available for use in judging raccoon population status, it was necessary to discover accurate, practical techniques for determining the age and sex of large numbers. In addition, a practical method for determining litter size in a large number of females was needed.

This study has attempted to discover practical techniques and apply them to the population during its present high level, in order that some of the biological factors present during the "high" could be compared with these during or after its decline. It is hoped that these comparisons will shed light on the causes for the fluctuations in the population. The application of the methods described here to the raccoon population of Missouri during its period of increase are reserved for a later paper.

METHODS

Several methods were used to obtain animals for study and examination.

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and University of Missouri cooperating. The study was made possible through a fellowship granted by the Edward K. Love Foundation. I am indebted to Dr. Wm. H. Elder, Associate Professor of Zoology, University of Missouri, under whose direction the investigation was made. Further acknowledgements are due as follows: to Mr. Herbert H. Dill, Manager of the Swan Lake National Wildlife Refuge, Sumner, Missouri for his spendid cooperation; and to Beverley C. Sanderson who assisted with all the field work.

Under favorable conditions during winter and spring, hunting without dogs, as described by Twichell and Dill (1949), proved to be efficient. With the aid of Herbert H. Dill, Refuge Manager, Swan Lake National Wildlife Refuge, Sumner, Missouri, and members of his staff, this method was used in April 1948 to secure animals for a captive colony, and was again employed during the winter of 1948–49 to secure returns from previously marked raccoons and to mark additional animals. A party of four men, including only one good climber, took as many as 15 animals in one day. The method is practicable only where there is a high population density, as was present on the Swan Lake Refuge.

In the summer of 1948, 56 animals were obtained on the Swan Lake Refuge with box-traps similar to the one described by Silver and Jarvis (1930). These traps were used because they were already available, but wire traps (*cf.* Stuewer, 1943a) would have been lighter and easier to handle; also it would have been easier to induce raccoons to leave them and enter the wire cone used to restrain the raccoons during examination.

Because it is difficult to retake a wild raccoon when wanted for examination, it was thought best to maintain a captive colony, making possible repeated examination of the same animals throughout the year.

Fur-buying establishments were valuable sources of information. Nearly 800 cased pelts were examined at four of them, to determine the age and sex of the animals from which the pelts came. Eighty-eight dead raccoons were examined at the establishment of Mr. J. R. Ruth, Downing, Missouri, who buys dead raccoons from hunters for pelting. Both carcasses and pelts are sold by Mr. Ruth. He provided weights of 61 additional animals and also saved penis bones from a large number of animals.

Whenever the writer handled a live or dead raccoon, he looked for external characters that might reveal its age or breeding history. All animals were weighed on dial-type dairy scales of 40-pound capacity. The penis bones and testes were measured. The length of the penis bone in a live raccoon can be measured accurately within five millimeters while an assistant holds the animal head-first in a wire cone. A six-inch, flexible, clear-plastic ruler is most convenient for measuring. The right thumb is placed against the base of the penis bone and the zero mark of the ruler is pushed against the thumb until the end of the ruler is even with the base of the bone. The ruler is held between two fingers of the right hand while the left forefinger is placed against the anterior end of the bone; the length is read by the position of the forefinger. The accuracy of these measurements was established by repeated measurements of captive adults and four males which were posted soon after their penis bones had been measured.

The teats of all females were examined for length and color as indications of the breeding history. Parous females had longer, darker teats than nonparous females. The reproductive tracts of all dead females were removed and examined for placental scars.

One object of this study was to measure the validity of placental-scar counts as a measure of litter size. To do this, it was necessary to have females which bore known numbers of young. Six captive females, captured in the wild

while pregnant, were available for examination. To avoid sacrificing an animal for one observation, laparotomies were performed.

It was important to anesthetize the females and perform the laparotomies soon after removing them from their cages, because this prevented distension of the bladders which interfered greatly with examination of the uteri. In the fall, extensive fat deposits often gave difficulty.

An effort was made to collect as many penis bones as possible during the 1948–49 hunting season. The Conservation Agents, Missouri Conservation Commission, were asked to supply the names of raccoon hunters in their respective districts, and names of others were secured locally. The hunters were sent instructions by letter before and after the hunting season (Dec. 1–Jan. 15). Only 13 hunters out of more than 200 contacted collected any material; however, these 13 contributed 79 penis bones.

The best source of raccoon penis bones was found to be dealers who bought the dead animals whole and sold carcasses for meat as well as pelts. Three hundred bones were collected from one establishment and nearly 200 from another during the hunting season of 1948–49. This was the first year collections were made, and 548 penis bones were collected.

Fresh penis bones are cleaned best with a pen-knife. The dried bones were either scraped or soaked overnight in a 10 per cent solution of potassium hydroxide as suggested by Friley (1947). If they were soaked, they were washed with water for several minutes before cleaning in order to remove the potassium hydroxide. After the particles of flesh were removed, the bones were placed in five per cent acetic acid for about a minute to neutralize any trace of potassium hydroxide; they were then washed with water again. This left the penis bone clean and ready for measuring before storage.

Sex and Age Determination

Sex determination in raccoons, alive or dead, is simple when close examination is possible. The penis bone is easily located by palpation. In the male the external urinary opening is several inches anterior to the anus, in the female it is not more than an inch anterior to the anus (Stuewer, 1943b). Usually large numbers of live and dead animals are not available, but there are large numbers of pelts at fur-buying establishments. Therefore, a method of sex determination employing raccoon pelts, like that of Buss (1941) for muskrats, was sought.

Sex can be determined in cased raccoon pelts only when there is not too much fat. A male pelt is easily recognized by the roughened area near the middle of the belly, marking the position of the preputial orifice in the live animal (Sisson, 1921: 572, 583). A female pelt is recognized by the absence of this mark and by the shrunken teats showing through on the fleshy side. Some males also have small teats showing on the leather side of the pelt. If the pelt is free of fat, sexing by the pelts is easy; but at the low pelt-price prevailing during this study many hunters removed no fat, making sex-identification difficult. Most doubtful pelts proved to be those of females; they could be positively identified by running the hand inside the cased pelt and feeling for the teats.

Determining sex in flat skins is not practicable because they are split down the mid-line of the belly, obliterating the mark left by the penis. In addition, stretching and nailing flat pelts often causes the edges to curl and makes it impossible to see the remnants of teats.

Unfortunately, age determination is not as simple or easy as sex determination. Although many raccoons have been maintained on game farms, reared by clubs, and kept as pets, no practicable and reliable technique for determining age has been reported. In Michigan Stuewer (1943a) explored the growth rates of the ear and hind foot of the raccoon as possible aging techniques, but found that both reached adult size by early fall. He believed it safe, with few exceptions, to consider animals with unworn upper canines less than 10 mm. long as young of the year. He also believed that raccoons with well-worn teeth were probably three or more years old. These measurements are not sufficiently accurate for age determination, and it is difficult to secure enough skulls to obtain a sample of the population, because few hunters bother to save them and carcasses sold for meat must have the head attached.

Recently penis bones have been used to separate males of some species into age classes. Deanesly (1935) reported that the os penis of the stoat (*Mustela erminea*) served to distinguish adult males. Wright (1947) reported that juvenile and adult penis bones of the long-tailed weasel (*Mustela frenata*) can be distinguished on the basis of weight, or appearance alone. Friley (1949a) reported that penis bones of the river otter (*Lutra c. canadensis*) can be placed into four age-groups on the basis of length, weight, volume, and general conformation. He also reported (Friley, 1949b) that by using both skull and bacular measurements, it was possible to separate beaver (*Castor canadensis michiganensis*) into three age classes in the spring. Important bacular measurements are length, weight, height of the proximal end, and head/tail-length ratio.

In the present study it was also found that the penis bones from raccoons could be classified as from adult or juvenile animals by means of length, weight, and conformation. A more accurate criterion, however, is the cartilaginous or bony distal end of the penis bone. Presence of cartilage on the distal end during the fall and winter marks an animal less than one year old, while a bony distal end marks an animal more than one year old. If the cartilage has been removed from the bone of a juvenile animal by cleaning, it can still be recognized as that of a young male by its truncated end, the bone of the adult being rounded or pointed (Plate 11A). More than 99 per cent of the bones could be "aged" at a glance and the few difficult ones could always be classified upon closer examination.

Although returns from tagged animals were not enough to prove the accuracy of the cartilage criterion, other data to be presented support its reliability as an age criterion.

The penes of five captive juveniles showed the characteristics of juveniles until late February. This suggests that the penis bone is reliable for "aging" males until February in Missouri.

In addition to the presence or absence of cartilage, the length and weight of the penis bone, air-dried for at least a

week, proved to be a reliable means of age classification in 98 per cent of the cases (Fig. 1). When all cleaned and dried penis bones less than 90 mm. long were considered juvenile, only 10 out of 545 (1.8 per cent) were not in agreement with the cartilage classification (Fig. 1A). When all those weighing two grams or less were considered juvenile, only eight out of 545 (1.5 per cent) were not in agreement with the cartilage classification (Fig. 1B). Consequently weight, length, or presence of cartilage can be used to separate penis bones into two age classes and thus to determine the age-composition of the harvest with unusual accuracy.

At present there is no need to weigh or measure penis bones from raccoons because use of the cartilage character is much easier and faster and rarely requires complete cleaning. Only if length, weight, or conformation prove to be helpful in separating the bones into more than two age classes will it be necessary to clean and measure the bones in future studies. Raccoon penis bones are of various sizes and shapes (Plate 11A); apparently as in otter (Friley, 1949a) the basal area of a raccoon penis bone becomes roughened and enlarged as the animal becomes older.

Approximately one per cent of the raccoon penis bones collected during this study had been fractured at some time (Plate 11B). The five penis bones shown in Plate 11B had been broken and healed prior to the death of the animals—the only cases among 545 bones. A few others were found with irregularities like slight bends or constrictions; the cause is unknown.

Because there was so little overlap in weight or length of penis bones with and without cartilage, it was apparent that these two groups represent animals of two age-/or breeding classes. That they are age classes was indicated by the fact that all males become sexually mature and lose the cartilage from

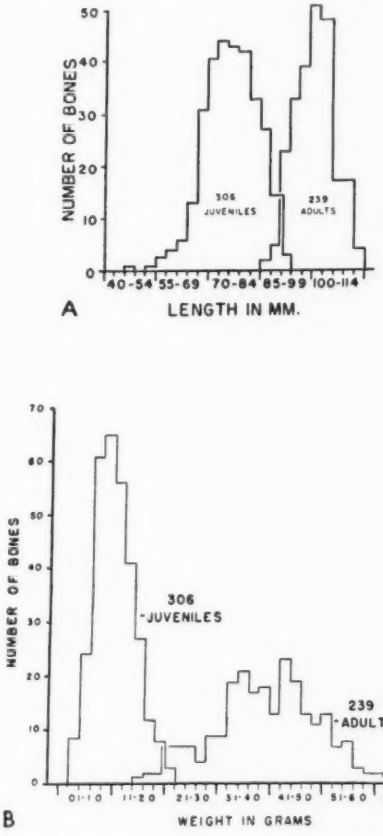

FIG. 1. A. Length distribution of penis bones of adult and juvenile males collected during the 1948–49 hunting season in Missouri. Animals classified by the presence or absence of cartilage. B. Weight distribution of the penis bones shown in A.

their penis bones before their second fall.

The shapes of the curves of weight and length distribution in adult penis bones indicate that as an adult animal grows older, the penis bone increases

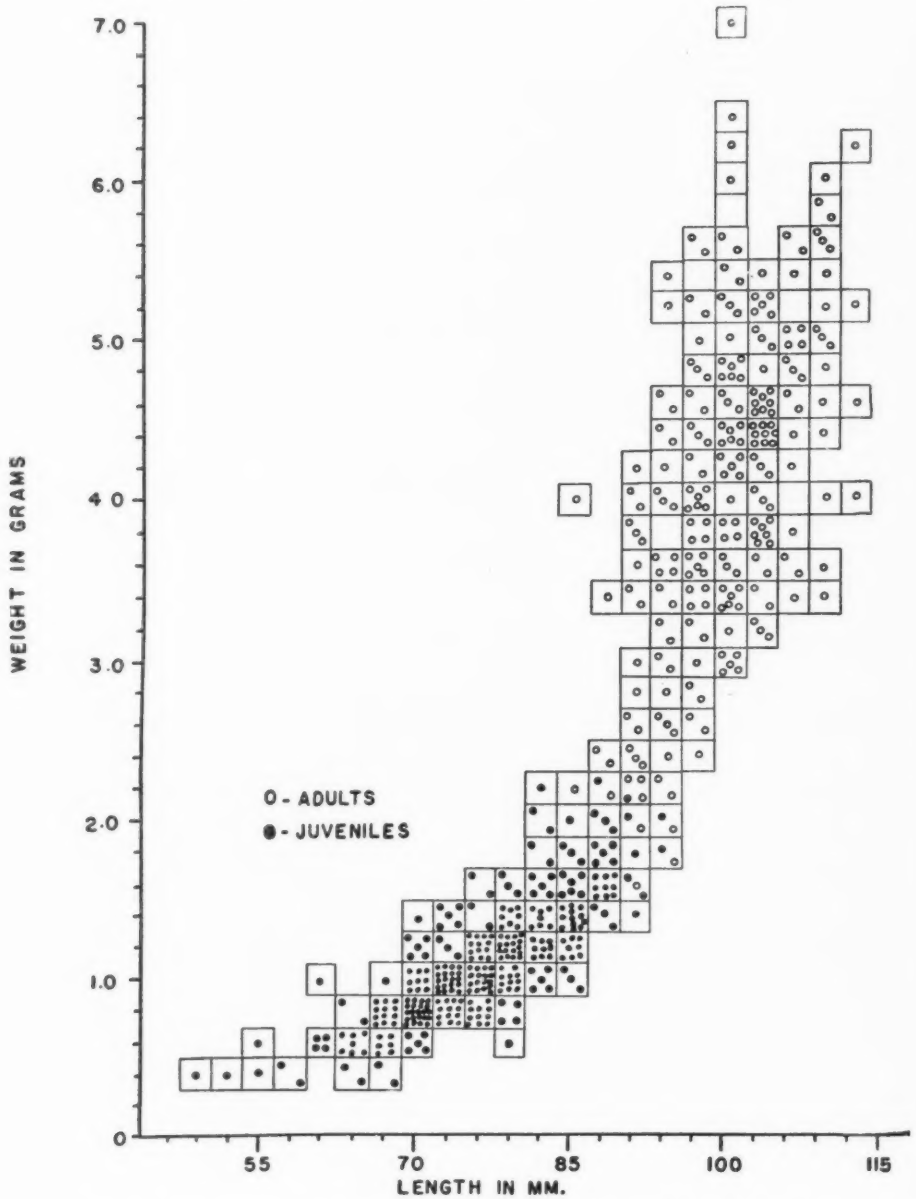

FIG. 2. Scattergram showing the relationship between weight and length of penis bones with and without cartilage.

little in length but continues to increase in weight (Fig. 1A and 1B). Figure 2 shows that as the bones of juveniles grow longer they become heavier, but that adult bones become heavier with no increase in length. This indicates that once a raccoon has reached sexual maturity and the cartilage on the distal

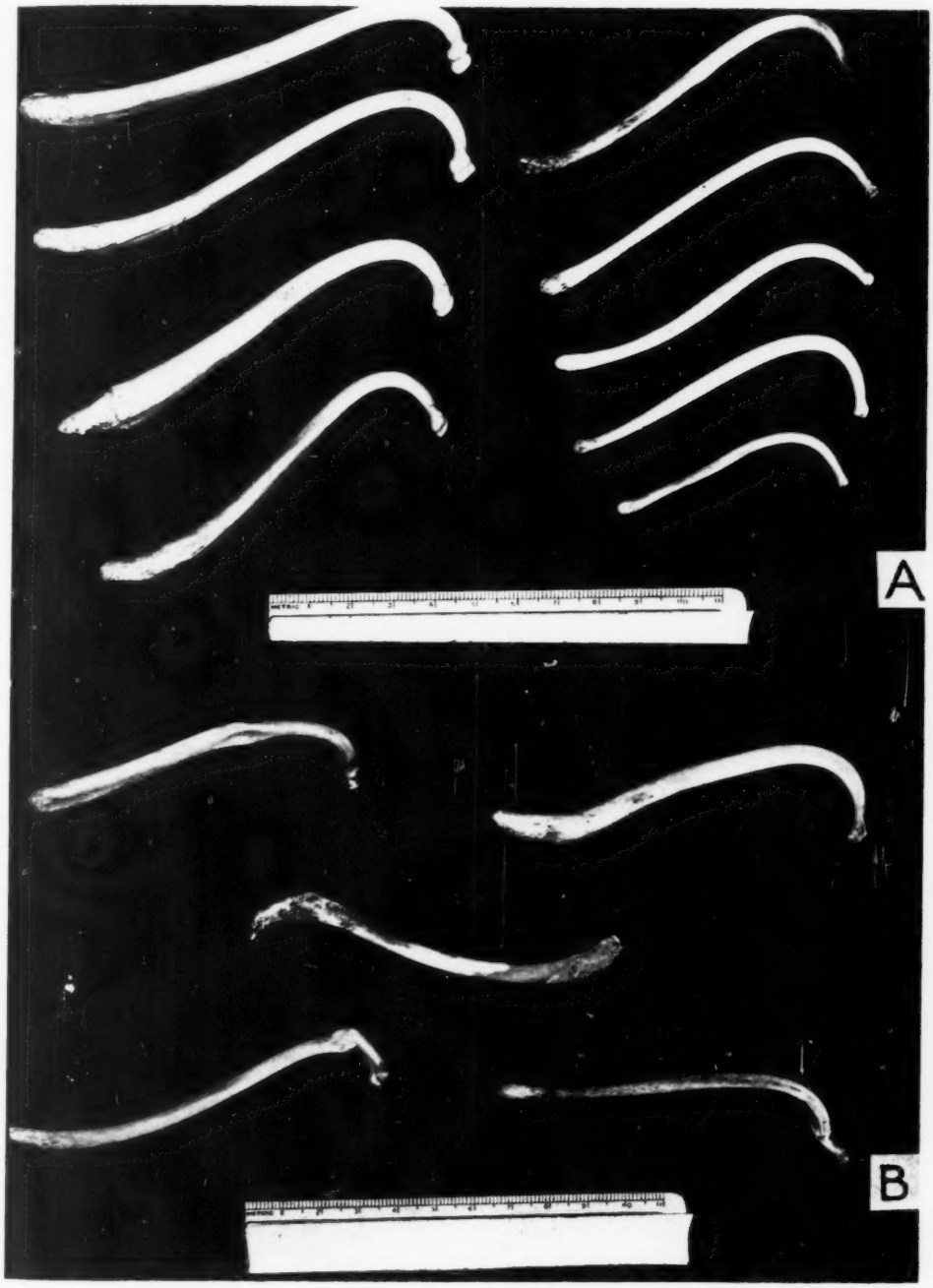

PLATE 11. A. Morphological differences in penis bones of adult and juvenile raccoons. Note slender base and truncated tip of juveniles on the right, as compared with the massive base, heavier shaft, and ossified, bifurcated tip of the adults on the left. B. Abnormal penis bones.

TABLE 1.—BIWEEKLY AVERAGE WEIGHTS AND LENGTHS OF PENIS BONES WITH AND WITHOUT CARTILAGE. BONES FROM DOWNING, MISSOURI

Date	Bones with cartilage (juveniles)			Bones with no cartilage (adults)		
	Av. Wt. (gms.)	Av. Length (mm.)	No. of Bones	Av. Wt. (gms.)	Av. Length (mm.)	No. of Bones
Dec. 1–15	1.0	63.3	82	4.1	100.5	46
Dec. 16–31	1.0	75.3	69	4.3	100.9	43
Jan. 1–15	1.1	78.0	23	3.9	100.9	36

end of its penis bone ossifies, the bone no longer increases in length but does become more massive. Friley (1949a) reported that development of otter penis bones from the "younger adult" to the "older adult" condition involved increase in length, weight, and volume. Presumably the "younger adults" were sexually mature.

Table 1 shows that penis bones from juvenile animals grow rapidly in length during December and January, but that adult bones show no increase in length or weight during this period. As might be anticipated, juvenile bones do not become appreciably heavier during this period of rapid growth in length.

During December, juvenile male raccoons seem to start rapid development toward sexual maturity. This period coincides with the rapid elongation of the penis bone (Table 1), the ossification of cartilage on its anterior end, and the enlargement of the preputial orifice (*cf.* below).

Examination of nearly 200 raccoon penis bones taken near Burlington, Iowa, during a period of years before the 1948 hunting season showed that the penis-bone characters described above are valid in other areas (Fig. 3). The dividing point between juvenile and adult lengths is the same (90 mm.) in both Missouri and Iowa (Figs. 1A and 3A). However, the dividing point between juvenile and adult weights is 2.0 grams in Missouri and 2.6 grams in Iowa (Figs. 1B and 3B). Perhaps this is explained by the fact that all the bones from Iowa came from the southeastern part of the state, and Nagel

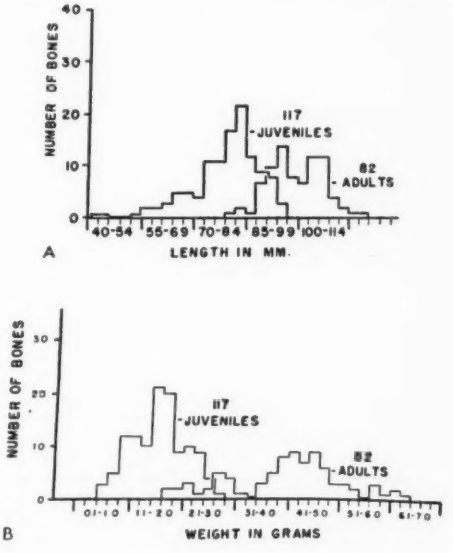

FIG. 3. A. Length distribution of penis bones of adult and juvenile males collected over a period of years prior to the 1948 hunting season near Burlington, Iowa. B. Weight distribution of the penis bones shown in A.

(1943) has reported that in nearby northeastern Missouri raccoons are heavier than elsewhere in the state.

The intact penis affords an accurate, convenient method for separating either live or dead males into two age classes during the hunting season. If the penis

can be extruded easily through the preputial orifice during fall and winter, the animal is more than one year old. In the fall the preputial orifice in a male of the year is usually too small to permit even the tip of the penis to be extruded. During late December and all of January the preputial orifice enlarges, but juveniles can still be distinguished from adults at this time because the penis is first freed at its anterior end and can be extruded only about half an inch. Thirty-eight male carcasses were examined at Downing, Missouri, during the 1948–49 hunting season; no bones from extrusible penes, and all those from non-extrusible penes, showed cartilage.

Five captive juveniles were examined periodically to determine how long the penis criterion remains valid. February 24 was the earliest date on which any preputial orifice was large enough to allow free passage of the penis. Three of the five penes could not be extruded in late February, but on March 24 all five could be extruded.

The time at which the last preputial orifices enlarge enough for the penes to be extruded in wild raccoons is unknown. After February, males with penes which *cannot* be extruded are juvenile; however, those whose penes *can* be extruded may be either adult or juvenile. A juvenile male is apparently sexually active as soon as its penis can be completely extruded, because some juvenile males with non-extrusible penes had motile sperm in their epididymides in January.

Stuewer's (1943a) information on age determination by body weight does not exactly fit Missouri conditions. He said that Michigan raccoons weighing less than 14 pounds in the fall could be safely called juvenile. He did not suggest that sex or breeding history influenced body weight, but in Missouri females as a group were lighter than males, and breeding history had a marked effect on the weight of adult females.

Figure 4A indicates that body weight is a fairly accurate means of dividing male raccoons into two age classes in Missouri. Juveniles classified by means of their penis bones weighed from 5 to 19 pounds, and adults from 10 to 26 pounds (1948–49). It is clear, then, that males weighing 15.0 pounds or more are usually adult, and that males weighing less than 15 pounds are usually juvenile. Taking 15 pounds as the boundary, only 15 of the 155 males would have been placed in the wrong age-class. This error of 10 per cent is no greater than that in most techniques for aging wild animals. Body weight is a convenient method for the inexperienced worker to use in estimating the age of live male raccoons.

Because the strain of pregnancy and lactation have a marked effect on female raccoons, their body weight was of little value as an age criterion. Figure 4B shows weight data from 67 females classified as parous or nonparous by the condition of the teats. Weights of the parous females ranged from 9.5 to 15.4 pounds with the mode at 10 to 11.9 pounds; while non-parous females, including young of the year and non-parous adults, ranged from 5.5 to 19.0 pounds in weight.

Weight data from 112 females taken in Missouri during the 1948–49 hunting season are shown in Figure 4C. These include all female body weights without regard to breeding history. The weight curve shows two peaks, of which the

first is formed by both young of the year and light parous females, the second by heavier parous females and all non-parous adult females. Figure 4 (B and C) shows why weight is not a valid age-criterion in female raccoons.

According to Stuewer (1943a), "Size of teats is probably a good criterion for separating yearling and older females in spring. Teats of yearlings remain small until the animals have borne young." With some modifications, the present study confirms his findings. In the late fall and winter, animals with long, dark teats are parous adults; however, some parous adults have non-pigmented teats of intermediate size. Such females are probably yearlings or two-year-olds which nursed litters for only a short time before losing them. Animals with small teats in fall and winter include both young of the year and non-parous females approximately 20 months old.

Care must be taken if teats are used to separate females into age classes during the spring. Evidence from the captive colony shows that when non-parous females come into heat, their teats become stimulated until they are almost identical with those of some females that have given birth to litters the previous spring. The only discernible difference between the teats of these two classes is that those of non-parous animals are turgid, pointed, and sometimes have a faint line of infolding at the base of the nipple. With experience it is possible to distinguish parous and non-parous classes in the spring by the appearance of the teats, but not all females with small, light-colored teats at this season are non-parous.

Examination of 33 female carcasses at Downing, Missouri, and of six captive females indicated that the appearance of the reproductive tract can be used during the hunting season in Missouri to distinguish the same two classes. The six captives were known to

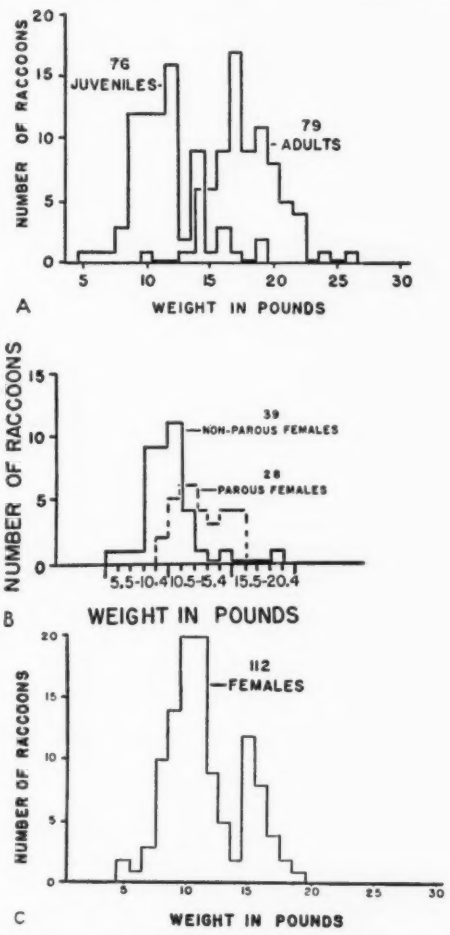

FIG. 4. A. Body weight distribution of juvenile and adult males collected during the 1948–49 hunting season in Missouri. Animals classified by the presence or absence of cartilage. B. Body weight distribution of parous and non-parous female raccoons weighed during the 1948–49 hunting season in Missouri. Breeding history determined by examination of the mammae. C. Bimodal distribution of female body weights taken during the 1948–49 hunting season in Missouri.

have given birth to litters, and 14 of the 33 female carcasses examined were called parous from the appearance of the teats. Thus, from examination of 39 uteri it was learned that parous females have opaque uterine horns 4 to 7 mm. in diameter, with placental scars, while non-parous females have translucent uterine horns, 1 to 3 mm. in diameter, without placental scars.

From these data it seems clear that with the body weight and examination of either the teats or the reproductive tract females can be separated into young of the year and older age classes during the hunting season in Missouri. Weight is necessary only for non-parous females because parous animals are adult regardless of their body weight. Because the break in the weight curve for non-parous females comes at 11.5 pounds (Fig. 4B), it seems that in 1948–49 at least, females with small teats and weighing 11.5 pounds or more were adult, while females with small teats and weighing less than 11.5 pounds were juvenile. Apparently the error was less than 10 per cent when this method was used to separate females into age classes because sixty-seven females classified by this method were found to be 48 per cent young of the year, while a sample of 545 males classified by the penis bone criterion, there were 56 per cent young of the year. There is no reason to believe that the age composition is different in the two sexes.

The os clitoridis seemed to offer possibilities for determining the age of female raccoons, although Rinker (1944) reported that its presence in the raccoon was not an age characteristic. Approximately 100 clitoria that should have contained the ossa clitoridum were collected during this study. In all of them only one bone was found, and it was no longer than one millimeter. Since the bones might have been missed in dissection (although Rinker *op. cit.* found the os clitoridis to be as large as 4×18 millimeters), clitoria of several animals were examined under a fluoroscope, but no bones were seen. At present it does not appear likely that this character will indicate the animal's age.

During the hunting season, when large numbers of carcasses may be available for examination, it is possible to recognize three classes of females: parous adults, non-parous adults, and young of the year. No single method does this, but with a combination of the criteria described above it can be done with considerable accuracy.

In Michigan, juvenile pelts are usually not prime until December, while most adult pelts are prime by mid-November (Stuewer, 1942). Stuewer did not suggest that primeness is an aging technique for raccoons as it was found to be for muskrats (Applegate and Predmore, 1947; Shanks, 1948). In Missouri, 98 per cent or more of the raccoon pelts are prime when the hunting season opens on December 1. Therefore, degree of primeness was of no help in age determination at this latitude.

VALIDITY OF PLACENTAL SCARS

"Placental scars," or "placental sites" as they are sometimes called, have been used to identify parous females and to determine numbers of young produced in some species of mammals. Deanesly (1935) reported, concerning the stoat (*Mustela erminea*), "It is possible to distinguish parous uteri both during and after involution by the presence of pigment granules in the epithelium of

the deeper-lying glands and in the stroma." Sooter (1946) counted placental scars to determine numbers of young muskrats produced, although no critical work has been done to find out whether the number of placental scars equals the number of young born in muskrats. Davis and Emlen (1948) found that in laboratory rats and wild brown rats placental scars were no more than a crude indication of the number of young produced. They reported as much as 100 per cent error in either direction when placental scar counts were used to determine litter size. Allen, Brambell, and Mills (1947) pointed out that if rabbit embryos die soon after implantation the placental sites may disappear before the birth of the remaining embryos. This raises the possibility that placental sites left by resorbed embryos might persist after parturition in the raccoon. Stuewer (1943b) autopsied a female raccoon in May and found four placental scars in the uterus; he believed they indicated that four young had been born.

The writer attempted to find the relation of placental scars in the raccoon uterus to the number of young that have been born. The uteri of six captive females which had produced known numbers of young were examined by laparotomy. In five of the six, the number of placental scars equalled the number of young born. The other female showed four placental scars and produced three known young, but when her litter was first observed, one of the young was partially eaten, suggesting that another may have been completely consumed. From this limited evidence, it appears that placental scars may be an accurate measure of litter size in raccoons.

Apparently all parous females have visible placental scars in their uteri during the hunting season in Missouri. Thirty-three females were examined at Downing, Missouri, during December and January; 14 were called parous from the condition of the teats and all 14 showed placental scars. None of the 19 classified as non-parous after examination of the teats had placental scars.

Perhaps placental scars in raccoons persist after the following breeding season. If they do, it should be possible to determine the litter size for more than one year from a raccoon's uterus, and to determine the percentage of females that have given birth to more than one litter. A captive adult whose breeding history was known for the previous year was autopsied on February 12, 1949. She had borne four young on April 26, 1948, and had shown four placental scars during a laparotomy on October 11, 1948. During the autopsy, four placental scars were visible, but when the uterus, stimulated at estrus, was opened, three additional pigmented areas were found. Two of these areas were in one uterine horn, one in the other. The pigment in these areas was in the mucosa and did not show on the outside. In view of evidence from other females, presented below, it is likely that these three pigmented areas represent placental scars from the 1947 breeding season.

The uteri of two parous captive females were examined by autopsy on April 12 and April 22. Each had borne three young the previous April, and each had shown three placental scars when examined by laparotomy a few months before. After death, no placental sites were visible in either uterus; however, when the uteri were

opened three pigmented areas were plainly visible in each. They were in the mucosa like those of the female just described.

One may conclude that placental scars visible on the outside of the uterus do not persist for more than one year; thus litter size for the preceding season may be accurately determined at autopsy. It also seems likely that examination of the inner surface of the uterus will permit classification of adult females into two age groups—those having bred for the first time and those having bred two or more years.

TABLE 2.—AVERAGE LITTER SIZE OF MISSOURI RACCOONS, 1948

No. of Litters Born in Captivity[1]	No. of Young	Parous Females Examined for Placental Scars[2]	Number of Placental Scars
8	28	14	56
Average litter size	3.5		4.0
Total average litter size		3.8	

[1] From females bred in the wild.
[2] Examined January 1–15 at Downing, Missouri.

MORTALITY

In addition to indicating the number of young born, placental scars aid in measuring juvenile mortality. It should amount, roughly, to the difference between the number of placental scars per parous female in the harvest and the number of young animals per parous female in the harvest. Because the natural enemies of the raccoon—fishers according to Seton (1929: 252) and wolves and bobcats according to Preble (1941)—have practically disappeared, it appears that both juvenile and adult natural mortality are low. Stuewer (1943a) marked 11 raccoons in the den when they were between three and ten weeks old, and all were still alive in mid-summer or later. He thought that the natural mortality in the whole population was less than 20 per cent of the fall kill by hunters.

The limited information collected during this study by means of live trapping and placental scar counts also indicated that natural juvenile mortality in raccoons is low. Seven pregnant females captured on the Swan Lake Refuge in early April, 1948, were kept in captivity and gave birth to litters averaging 3.5 young (Table 2). During live trapping on the Refuge in the summer of 1948, nine lactating females and 32 young animals were trapped. This is the same ratio: 3.5 young per breeding female. It suggests that juvenile mortality from birth to summer is low, but both samples are too small to be conclusive.

A different picture comes from a sample of 54 raccoons of both sex-/and age groups, examined at Downing, Missouri, January 1–15, 1949. Of the 54, 14 had borne litters; their placental scars numbered from one to six averaging four. Twenty-seven of the 54 were juvenile, a ratio of only two young per parous female. This would suggest a juvenile mortality of 50 per cent between birth and January. That hunting

is the principal cause is indicated by the following information: Of 237 males taken in December, 56.5 per cent were juvenile; of 64 males taken January 1–15, only 37.5 per cent were juvenile. This means that in December juveniles were caught in a higher proportion than in January, and that the early part of the hunting season probably accounted for most of the juvenile mortality.

The applications of the techniques described in this paper to population turnover, harvest records, percentage of females breeding, and other factors in the Missouri raccoon population are to be presented in a later paper.

SUMMARY

1. In raccoons, alive or dead, males are easily recognized by the presence of testes and a penis bone. In females the mammae, the conspicuous vulva, and the absence of the penis bone are diagnostic.

2. In cased pelts which do not have too much fat, males are easily recognized by the roughened area near the middle of the belly marking the position of the preputial orifice. Females are recognized by the absence of this character and by pigmented spots marking the location of the teats.

3. Nearly 800 penis bones gathered in Missouri were studied in the search for an aging technique. The presence of cartilage on the distal end of the penis bone during fall and winter marks an animal less than one year of age, while its absence marks an animal more than one year of age.

4. Length and weight of the dried penis bone also was used as an age-criterion in 98 per cent of the cases.

5. Examination of nearly 200 penis bones from Iowa showed that the use of the penis bones as an indicator of age is not confined to one area.

6. During the fall and winter the penis affords an accurate and convenient method for distinguishing two age classes in live and dead males. If the penis can be extruded easily through the preputial orifice, the animal is more than one year old. If the penis cannot be extruded, or if it can be extruded only slightly without force, the animal is less than one year old. This technique is reliable in Missouri until February.

7. During the Missouri hunting season, body weight can be used to separate males into age classes with only 10 per cent error by considering animals weighing 15.0 pounds or more as adults.

8. Body weight alone is of little value as an age-criterion in female raccoons in Missouri.

9. Examination of female teats or reproductive tracts distinguish parous from non-parous groups during the fall and winter in Missouri. Parous females have long, dark teats and placental scars in their uteri, while non-parous females have short, non-pigmented teats and no placental scars in their uteri.

10. Body weight plus examination of the teats or reproductive tracts can be used to classify females in fall and winter as parous adults, non-parous adults, and young of the year. Non-parous females weighing less than 11.5 pounds are young of the year, while those weighing 11.5 pounds or more are adult. Parous females are, of course, adult regardless of their body weight.

11. An os clitoris was found in but one of 100 clitoria examined; it can serve no use as an age criterion.

12. In cased pelts, those from parous females can be recognized by the large,

dark teats which show through to the fleshy side. Teats of non-parous females are small, whitish spots similar to the spots sometimes seen on male pelts.

13. Primeness of the pelt was not related to age classes; nearly all raccoon pelts are prime in Missouri when the hunting season opens on December 1.

14. Laparotomies performed on six females which had given birth to known numbers of young indicated that the number of placental scars equals the number of young born to raccoons.

15. Juvenile mortality is very low between birth and summer, but it amounts to approximately 50 per cent during the first year. Most of this mortality is believed to be the result of hunting.

LITERATURE CITED

ALLEN, PATRICIA, F. W. ROGERS BRAMBELL, and IVOR H. MILLS. 1947. Studies on sterility and prenatal mortality in wild rabbits. Journ. Exp. Biol., **23**(3&4): 312–331.

APPLEGATE, VERNON C. and HENRY E. PREDMORE, JR. 1947. Age classes and patterns of primeness in a fall collection of muskrat pelts. Jour. Wildl. Mgt., **11**(4): 324–330.

BUSS, IRVEN O. 1941. Sex ratios and weights of muskrats (*Ondatra z. zibethica*) from Wisconsin. Journ. Mammalogy, **22**(4): 403–406.

DAVIS, DAVID E., and JOHN T. EMLEN, JR. 1948. The placental scar as a measure of fertility in rats. Jour. Wildl. Mgt., **12**(2): 162–166.

DEANSLY, RUTH. 1935. XI—The reproductive processes of certain mammals. Part IX—Growth and reproduction in the stoat (*Mustela erminea*). Phil. Trans. Roy. Soc., London, Ser. B., 225, no. **528**: 459–492.

FRILEY, CHARLES E., JR. 1947. Preparation and preservation of the baculum of mammals. Journ. Mammalogy, **28**(4): 395–397.

———. 1949a. Age determination, by use of the baculum, in the river otter, *Lutra c. canadensis* Schreiber. Journ. Mammalogy, **30**(2): 102–110.

———. 1949b. Use of the baculum in age determination of Michigan beaver. Journ. Mammalogy, **30**(3): 261–267.

LEOPOLD, ALDO. 1933. Game Management. Charles Scribner's Sons, New York.

NAGEL, WERNER O. 1943. How big is a 'coon? Mo. Conservationist, **4**(7): 6–7.

PREBLE, NORMAN A. 1941. Raccoon management in central Ohio. Ohio Wildlife Res. Sta. Release No. 161, 9 pp. (Mimeo).

RINKER, GEORGE C. 1944. Os clitoridis from the raccoon. Journ. Mammalogy, **25**(1): 91–92.

SETON, E. T. 1929. Lives of game animals. Vol. II, Doubleday, Doran and Co., Inc., New York.

SHANKS, CHARLES E. 1948. The pelt-primeness method of aging muskrats. Amer. Midl. Nat., **39**(1): 179–187.

SILVER, JAMES and FRANK N. JARVIS. 1930. How to make a cat trap. Bur. Biol. Survey, Leaflet No. 50, 4 pp.

SISSON, SEPTIMUS. 1921. The anatomy of domestic animals. W. B. Saunders Co., Philadelphia and London.

SOOTER, C. A. 1941. Muskrats of Tule Lake Refuge, California. Jour. Wildl. Mgt., **10**(1): 68–69.

STUEWER, FREDERICK W. 1942. Studies of molting and priming of fur of the eastern raccoon. Journ. Mammalogy, **23**(4): 399–404.

STUEWER, FREDERICK W. 1943a. Raccoons, their habits and management in Michigan. Ecol. Mon., **13**(2): 203–257.

———. 1943b. Reproduction of raccoons in Michigan. Jour. Wildl. Mgt., **7**(1): 60–73.

TWICHELL, ALLEN REED and HERBERT H. DILL. 1949. One hundred raccoons from one hundred and two acres. Journ. Mammalogy, **30**(2): 130–133.

WRIGHT, P. L. 1947. The sexual cycle in the male long-tailed weasel (*Mustela frenata*). Journ. Mammalogy, **28**(4): 343–352.

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MUSKRAT TRAPPING ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE, NEW YORK, 1943–1948

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Over a long period of years the extensive inland marshes of central New York have annually produced large numbers of muskrats. Due to the very large size, thick skin, and long, dense underfur of pelts from this area, they are much sought after by the fur trade. As these pelts are used primarily for making finest quality "Hudson seal" they always bring top market prices. The factors responsible for producing such extra large, heavy muskrats have long been the subject of considerable speculation. This has been especially true of those taken on the Montezuma National Wildlife Refuge near Seneca Falls, New York, where trapping of new impounded areas was initiated during the 1943 spring season. The catch of 213 males and 161 females from March 16 to 20 of that year showed the remarkable weight average of 3.4 and 3.1 pounds respectively. The majority of all pelts from this refuge annually grade "XX Large" and "XXX Large" at the fur auctions and represent the largest skins received from any section of the country. It was at first thought that the remarkable weights of these muskrats might be largely due to the fact that the majority represented possibly unusually old individuals attracted to the water and food of the impounded areas, which stood out like oases during intense droughts of the preceding two summers. It soon became evident, however, that animals of all age classes were very fat and there also appeared to be an accelerated growth rate. This was traceable directly to a continuous winter food supply of tender, green, 4 to 5 inch, growing points or young dormant shoots of cattail beneath the ice. These contain chlorophyll, are undoubtedly high in protein and growth-promoting substances, and are believed to largely account for such rapid growth and maximum weights. That these shoots formed a substantial part of their diet was evidenced by the abundant remains found in most of the feeding huts or shelters examined.

The area in question has been briefly described (Dozier, 1945), the most important food plants listed, and the 1943 and 1944 annual catches, sex ratios, and average weights given in bi-weekly periods. The preferred food plant was shown to be the dominant "blue or Cooper's flag" cattail (*Typha glauca*) (see Hotchkiss & Dozier, 1949), with "soft flag" (*Typha latifolia*), burreed (*Sparganium eurycarpum*), three-square bulrush (*Scirpus americanus*), hard stem bulrush (*Scirpus acutus*), river bulrush (*Scirpus fluviatilis*) and sweet flag (*Acorus calamus*) following in order of utilization.

Through the continued kind and whole-hearted cooperation of the Refuge Manager, Merton Radway, and his staff, valuable comparative data have been obtained each trapping season for the period 1943–1948. This paper presents a tabular analysis of the accumulated data together with a brief discussion of methods employed in harvesting the muskrat fur crop. Over the

6-year period a total of 31,867 muskrats was taken during the legal trapping season—January 1 to March 20.

SEX RATIO

The catch was not segregated into age classes. A small percentage was brought in from the trap lines in a condition unsatisfactory for accurate sexing and weighing and therefore records of these were discarded. A total of 14,911 males and 15,001 females was sexed by a careful check of the external genitalia. There was a slight preponderance of males to females in the first 3 years. The summary for the 6-year period in Table 1 shows a 50:50 ratio of the sexes. This is in marked contrast to that previously reported (Dozier and Allen, 1942, and Dozier, Markley and Llewellyn, 1948) in summarizations of sex ratio references in the literature, most of which indicate an excess of males in the catch, and more recently, by Heit (1949) who reported a ratio of 198 males (72 per cent) to 77 females (28 per cent) in a catch of 275 muskrats during 1939–1940 from a Wayne County, New York, marsh. This county, together with those of Cayuga and Seneca, form a triangle in which lies the low basin of muck land known as the Montezuma marshes.

It is difficult to explain why a 6-year average sex ratio approaching 50:50 should occur on the Montezuma area while a similar 5-year study in Maryland showed a preponderance of 57 per cent males. Such differences in catch records may prove to be the result of varying weather conditions and trapping methods or possibly survival factors such as food and water supply, population densities, and sexual development. Most probably these do not represent the actual ratio at birth of

TABLE 1.—THE ANNUAL CATCH AND SEX RATIO OF MUSKRATS ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE, NEW YORK, 1943–1948

Period	1943				1944				1945			
	Catch		% ♂♂	♂♂ per 100 ♀♀	Catch		% ♂♂	♂♂ per 100 ♀♀	Catch		% ♂♂	♂♂ per 100 ♀♀
	♂♂	♀♀			♂♂	♀♀			♂♂	♀♀		
Jan. 1–15					381	375	50	102	582	523	53	111
16–31					572	487	54	117	465	490	49	95
Feb. 1–15					420	279	60	151	427	455	48	94
16–28					322	213	60	151	843	824	51	102
Mar. 1–20	339	296	53	115	457	413	52	111	1,530	1,297	54	119
Totals	339	296	53	115	2,152	1,767	55	122	3,847	3,589	52	107

Period	1946				1947				1948				Summary			
	Catch		% ♂♂	♂♂ per 100 ♀♀	Catch		% ♂♂	♂♂ per 100 ♀♀	Catch		% ♂♂	♂♂ per 100 ♀♀	Catch		% ♂♂	♂♂ per 100 ♀♀
	♂♂	♀♀			♂♂	♀♀			♂♂	♀♀			♂♂	♀♀		
Jan. 1–15	910	1,197	43	76	828	872	49	95	711	835	46	85	3,412	3,802	47	90
16–31	1,177	1,287	48	91	958	1,143	46	84	394	496	44	79	3,566	3,903	48	91
Feb. 1–15	847	855	50	99	682	717	49	95	131	161	45	81	2,507	2,467	50	102
16–28	275	247	53	111	412	429	49	96	301	321	48	94	2,153	2,034	51	106
Mar. 1–20	374	309	55	121	335	289	54	116	238	191	56	125	3,273	2,795	54	117
Totals	3,583	3,895	48	92	3,215	3,450	48	93	1,775	2,004	47	89	14,911	15,001	50	99

Total number of muskrats sexed for six year period—29,912.

the litter. The record of 54 per cent males among 68 kits in 10 litters examined by Heit in April and May 1940 and the contention of various trappers trapper on the same unit and the resulting catch would be almost entirely males on a certain day and the very opposite on the following day.

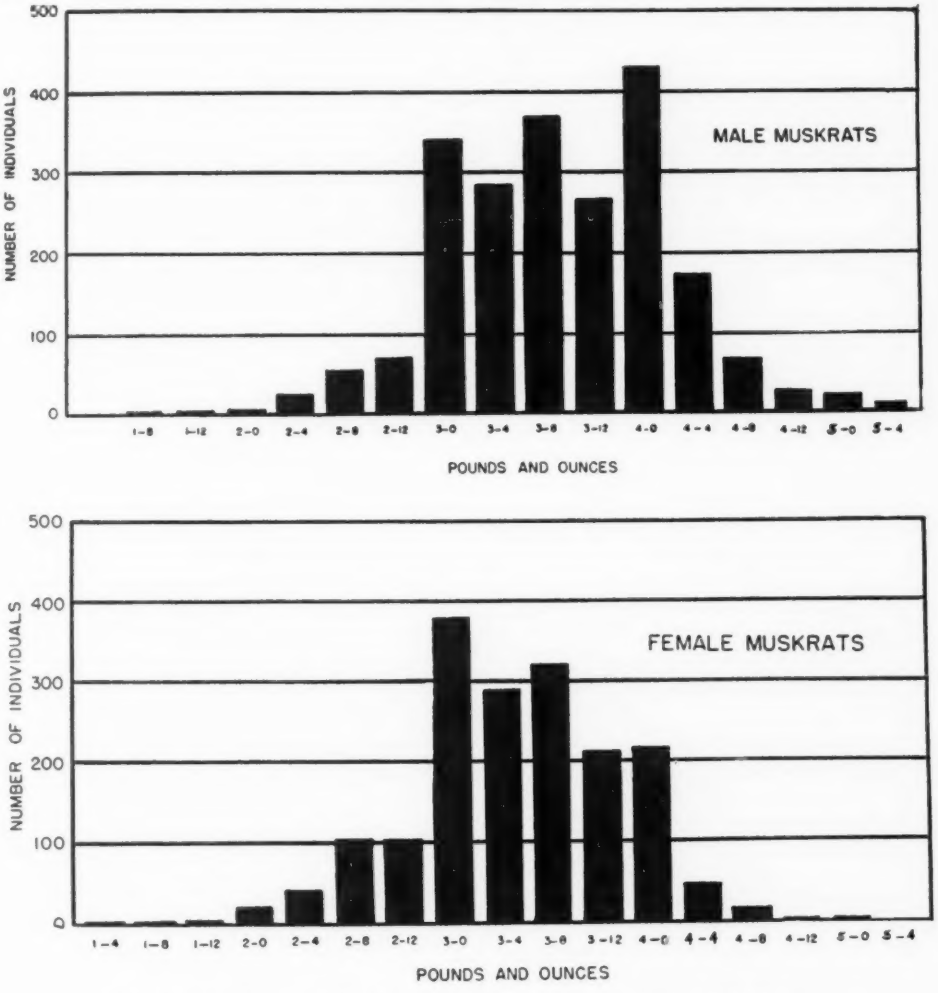

FIG. 1.—Numbers of male and female muskrats of 4-ounce weight groups, Montezuma National Wildlife Refuge, New York, 1944.

that certain types of trap sets will catch mostly males would tend to support this possibility. In Maryland, however, the writer sexed large daily catches wherein identical sets were made by the same

The preponderance of males over females generally increased each biweekly period as the season progressed for the first 3 years of the study but later the reverse occurred. During the

last weeks of each season more males than females were being taken, the reverse of the common belief prevailing among trappers but in close agreement with results reported on a similar 5-year study conducted in the tidal marshes of Maryland (Dozier, Markley and Llewellyn, 1948). This also is not in agreement with the statement by some New York trappers (Johnson, 1925) that at the latter part of the season male muskrats hide but females wander about and are more easily caught.

WEIGHTS

With the exception of a limited number of individuals that were damaged or mutilated by predators and scavengers and the partial records obtained for 1943, weights were secured on all muskrats trapped on the Montezuma Refuge from 1943–1948. Practically all of the daily catch was sexed and weighed the same evening the animals were brought in from the trap lines. Although some animals were wet, it is believed that this made no significant difference in the results as such animals were distributed approximately equally among the sexes.

Weighing of muskrats taken from the Montezuma Refuge was not initiated until the last few days of the 1943 season. Of 1,553 muskrats taken from March 16–20 that year, weights were obtained on only 213 males and 101 females. This limited harvest had little effect on the population of older age classes carried over into the following season and there were noticeably few small animals. The average weight increased from 3.25 in 1943 to the all-time high of 3.45 pounds in 1944. Weights obtained in that year on 3,919 animals had a range of from 1 pound 8 ounces (24 oz., 680 g.) to 5 pounds 4 ounces (84 oz., 2,381 g.) and mean of 3 pounds 10 ounces (58 oz., 1,644 g.) for 2,152 males; 1 pound 4 ounces (20 oz., 576 g.) to 5 pounds (80 oz., 2,268) g.) and mean of 3 pounds 5 ounces (53 oz., 1,503 g.) for 1,767 females.

The entire 1944 catch of 3,919 adults and young was graphically arranged for studying into 4-ounce weight groups. The weights were remarkably high, the largest number of males, 429, falling into a 4 pound (64 oz., 1,814 g.) weight group and 213 females into a corresponding weight group of 3 pounds 12 ounces (48 oz., 1,361 g.), an average difference of 4.8 ounces. Of 50 muskrats taken on a single day, March 7, 1944, 27 weighed 4 pounds or over, 2 weighed 5 pounds, and 1 weighed 5 pounds 3 ounces. An old male trapped January 29, 1944, weighed 5 pounds 4 ounces, the highest recorded. These 1944 records still stand as the heaviest muskrat weights yet known and show that optimum conditions for growth must have existed on the area at that time, as evidenced by the rapid growth, maximum weights and measurements attained, and heavy fat accumulation. There was a marked difference, however, in size, weight, and fatty condition of the muskrats coming from the rank "blue flag" cattail marshes of the lower main pool when compared with those from the upper storage pool where the water level was high and the food supply poor.

By 1946, habitat conditions were reversed to a large extent, with a nice stand of "blue flag" cattail present over the upper pool while certain areas on the lower pool had been badly eaten-out. On the latter areas cattail had largely disappeared and the small pop-

ulation of muskrats present was maintaining itself principally on the dense, submerged growths of coontail, *Ceratophyllum demersum*, as was evidenced by the remains in the feeding huts examined. Muskrats trapped on such areas that year were noticeably smaller and trappers reported finding some dead, uninjured muskrats inside of "feeders" it is possible that disease may have become a factor in reducing the catch and average weights that year.

Average weights on 29,651 muskrats are given in Table 2, arranged accord-

TABLE 2.—AVERAGE WEIGHTS (IN POUNDS) OF MUSKRATS ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE, NEW YORK, 1943–1948

Period	1943*			1944			1945		
	♂♂	♀♀	Combined	♂♂	♀♀	Combined	♂♂	♀♀	Combined
Jan. 1–15				3.38	3.28	3.33	3.11	3.09	3.10
16–31				3.38	3.18	3.29	3.13	2.99	3.06
Feb. 1–15				3.53	3.31	3.44	3.15	3.07	3.11
16–28				3.78	3.43	3.63	3.27	3.01	3.14
Mar. 1–20	3.37	3.07	3.24	3.86	3.43	3.65	3.15	2.94	3.05
Totals	3.37	3.07	3.24	3.57	3.31	3.45	3.17	3.00	3.09

Period	1946			1947			1948			Summary		
	♂♂	♀♀	Combined	♂♂	♀♀	Combined	♂♂	♀♀	Combined	♂♂	♀♀	Combined
Jan. 1–15	2.99	2.67	2.81	3.16	2.97	3.07	2.95	2.73	2.83	3.09	2.87	2.96
16–31	3.20	2.82	3.00	3.69	3.00	3.31	3.06	2.84	2.93	3.34	2.94	3.13
Feb. 1–15	3.30	3.00	3.20	3.35	3.18	3.27	2.93	2.66	2.78	3.31	3.09	3.20
16–28	3.46	3.00	3.25	3.38	3.16	3.27	2.86	2.69	2.77	3.33	3.03	3.19
Mar. 1–20	3.44	3.12	3.30	3.47	3.03	3.14	3.10	2.62	2.89	3.31	3.03	3.18
Totals	3.20	2.86	3.03	3.33	3.06	3.22	2.98	2.74	2.85	3.27	2.98	3.12

* 1943—based on only 213 males and 161 females.
Total number of muskrats weighed for six-year period—29,651.

weighed less than those of the preceding two years.

Food conditions improved again somewhat in 1947, with a corresponding increase in weights. Due to the very severe winter and most difficult trapping conditions existing that year, planned trapper quotas could not be attained. Again, in 1948 trapping conditions were the worst experienced over a long period of years, with severe freezing from 12 to 18 inches deep. The number of houses was greatly reduced over that of the previous count. Only about one-half of the anticipated catch was taken and the animals reached the lowest average weight and poorest condition of the entire study period. As several of the

ing to sex and bi-weekly trapping periods. The 14,785 males ranged from 1 pound 8 ounces (24 oz., 680 g.) to 5 pounds 4 ounces (84 oz., 2,381 g.) and averaged 3 pounds 4 ounces (52 oz., 1,474 g.) for the 6-year period. For the 14,866 females the range was from 1 pound 4 ounces (20 oz., 567 g.) to 5 pounds 4 ounces (84 oz., 2,381 g.) and the average was 3 pounds (48 oz., 1,361 g.).

There has always been a distinct sexual difference in weights, males averaging 13 per cent heavier than females, or approximately 4 ounces. In 1944 there was a very distinct increase in the weight of both males and females as the trapping season pro-

gressed, with a gradual decline the last week. During other years the pattern was not as consistent and a small weight loss took place during the last trapping period, March 1–20. Just prior to the spring "break-up," which usually occurs in Seneca County about March 14–18, the muskrats seem to quickly lose much of their accumulated fat and weight, apparently during the process of conditioning for early mating.

SEASONAL FLUCTUATION IN TRAPPING RESULTS

In computing Table 3 the incomplete data obtained in 1943 were omitted and the percentage of the catch by bi-weekly and monthly periods is based on 29,277 muskrats trapped during the 5-year period 1944–1948. With the exception of the 1945, season, from 46 to 65 per cent of the catch each year occurred during January (50 per cent average, 1944–1948). Both bi-weekly periods in this month were highly productive but fluctuated considerably from year to year, running for the period Jan. 1–15 from 15 per cent in 1945 to as high as 41 per cent in 1948 of the total annual crop. From 40 to as high as 84 per cent of the annual catch was taken during the first 6 weeks of the trapping season. Only 31 per cent of the average total catch was trapped in February during which month pelts of maximum size, full primeness and finest quality are obtained.

Regardless of the size of the muskrat population, experience and industry of the trapper, trapping success is dependant largely on prevailing weather conditions, such as rainfall, thickness of ice formation, deep snows, and periods of open water. Such variation is clearly reflected on the annual catch as shown in Table 3. The summary of 5 years trapping operations, however, gives what may be anticipated for each bi-weekly period. It is remarkable how closely the percentages for the various bi-weekly period averages in Table 3 tally with a similar summary for a 5-year study on *macrodon* conducted at the Blackwater National Wildlife Refuge in Maryland (Dozier, Markley and Llewellyn, 1948).

TABLE 3.—PERCENTAGE OF THE TOTAL MUSKRAT CATCH IN BI-WEEKLY AND MONTHLY PERIODS, MONTEZUMA NATIONAL WILDLIFE REFUGE NEW YORK, 1944–1948

Period	1944		1945		1946		1947		1948		Summary	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Jan. 1–15	756	19	1,105	15	2,107	28	1,700	26	1,546	41	7,214	25
16–31	1,059	27	955	13	2,464	33	2,101	31	890	24	7,469	25
Jan. 1–31	1,815	46	2,060	28	4,571	61	3,801	57	2,436	65	14,683	50
Feb. 1–15	699	18	882	12	1,702	23	1,399	21	292	8	4,974	17
16–28	535	14	1,667	22	522	7	841	13	622	16	4,187	14
Feb. 1–28	1,234	32	2,549	34	2,224	30	2,240	34	914	24	9,161	31
Mar. 1–20	870	22	2,827	38	683	9	624	9	429	11	5,433	19
Totals	3,919	100	7,436	100	7,478	100	6,665	100	3,779	100	29,277	100

Trapping Conditions, 1943–1948

1943—Extreme freeze-up with only a few days of favorable open weather at the end. Trapping conditions very difficult. 3 trappers caught 1,553 muskrats.

1944—Mildest and most favorable trapping conditions in over 30 years. Heavy snowfall in February and March. 3 trappers caught 3,988 muskrats.

1945—Discontinued setting traps inside of feeding huts and used improved set in approach leads. Weather opened up about February 24 and remained rather open for remainder of season. 5 trappers caught 7,988 muskrats.

1946—Season started unseasonably warm with no snow, and ice soft and unsafe early. Large catches were taken Jan. 10–12 during an open spell. Good trapping with 6–8 inches of ice. Heavy snowfall made it necessary to employ snow sleds. Spring break-up occurred March 15–16 and mating observed March 17, 18 and 19. 5 trappers caught 7,625 muskrats.

1947—Very severe winter conditions with 6–12 inches of ice and no real spring break-up until March 19. Rainfall and warm thaw Jan. 2–6 and Jan. 18–22. 6 trappers caught 6,915 muskrats. Trapping conditions were most difficult and planned quotas could not be attained.

1948—Severe deep freezing, with 12–18 inches of ice. Trapping conditions the worst in entire experience of older trappers. No warm spells or thaws during the season until a few days early in March. Spring break-up started March 18 but some ice was still present on March 21. Only a small amount of open trapping March 19–20. 5 trappers caught 3,789 muskrats.

TRAPPING AND HARVESTING METHODS

Trapping operations at the Montezuma Refuge have been handled by the manager and his assistant with the seasonal help of an inspector, several fur handlers and from three to six local trappers. The latter were employed on a 50:50 basis and each trapper skinned his daily catch at the central fur shed, with occasional help from the fur handlers. The legal muskrat trapping season for Seneca County, New York, runs from January 1 to March 20, inclusive. Therefore, trapping is usually conducted for the most part under frozen conditions. Hard freezing usually starts by the middle of December and continues until the late spring "thaw-out" or "break-up" which generally occurs around the middle of March.

Throughout a good part of the winter there are from 6 to 7 inches of ice and some years there may be from 12 to 18, often with heavy snowfall and much drifting. Trapping under such conditions is difficult and there is a set rule that the trap lines must be "run" each day. This requires proper equipment such as heavy clothing, rubber boots or waders, and a long-sleeved rubber glove in order to withstand the exposure to the intense cold, and an axe for cutting through the ice to set traps. Good use is made at times of a long box, rigged on sled runners, as an aid in getting in traps and poles, and for bringing large catches out of the frozen marsh. Under conditions of extreme snowfall and accompanying drifts, specially constructed toboggans or snow-float sleds are utilized for the same purpose.

Dirt mounds scattered along the edges of some main channels have proved very attractive to muskrats for denning purposes. Sets in approaches to these dens and along the leads into the dike slope or face are made by chopping through the ice and the animals caught in this manner are therefore practically all drowned. When the marsh is frozen solid most muskrats are caught by

sets made inside the feeding huts or just adjacent to these in the approach lead.

During the first two years of trapping on this experimental area, most sets were made inside the feeding huts or shelters. Such a set required removal of the crown of the feeding hut, with the pole placed at or near the center and the attached trap set at the edge of the feeding platform, covered with an inch or two of water, and the cap material replaced for daily examination and to avoid undue disturbance. After removal of a trapped muskrat and resetting, the cap should be carefully replaced around the pole, using in addition any of the feeding material available, and packed down tightly to insure against freezing out of other individuals which might be using the house. The trap is often sprung by the feeding material being brought in to the platform by the muskrat. Use of this set was under special permit as it is illegal under the New York State law to set traps within 5 feet of a muskrat house and no distinction was made between the "feeding hut or shelter" and the larger "dwelling or nesting house" (Dozier, 1948). Although highly satisfactory, this set was abandoned at the beginning of the 1945 trapping season as it was found that an even better set could be made by cutting through the ice into one of the leads entering the feeding hut and setting the trap at that point in such a position that the pan was tripped as the muskrat entered the structure. This newer set eliminated the tedious work of recapping the hut and also obviated many "freeze-outs" of structures damaged by the struggles of large muskrats that were not quickly drowned. As soon as the spring "thaw-out" or "break-up" arrives this form of trapping is abandoned for floating-board and other open water sets. Thin ice during such thaw-outs necessitates the use of very light weight boats, specially constructed of white cedar, with steel runners on the bottom for protection and for maneuvering on the thin ice.

HANDLING OF THE FUR AND MEATS

All animals were brought in daily to the central fur house where they were sexed, weighed and skinned. Several methods of pelting were employed by the various trappers such as skinning the animal on a board held between the legs while sitting on a bench or by suspending the muskrat by its tail, held by means of a looped cord. After the daily catch had been skinned, the pelts were then divided proportionately 50:50 by the inspector and the Refuge's share of skins was then suspended overnight on a series of nails or hooks by their nose tips, the fur side out, in order to dry sufficiently before stretching. The following morning the raw pelts were placed on a fleshing board form held in a bench vise, and the excess fat and any meat remnants removed with a specially devised steel "Montezuma" fleshing tool. In cases of such excessive fat deposition, fleshing becomes a necessity and the extra thick, tough skin of these New York muskrats permits the use of this tool which requires considerable downward pressure.

Pelts from the Montezuma Refuge were found to be so large that the ordinary steel stretcher in general commercial use could not be employed. During the early years an expandable wooden stretcher was designed and used but this was supplanted as soon as steel stretchers of sufficiently large size could be obtained. In line with the

war effort during part of the study period, all excess fat from fleshing operations was saved and sold to a local rendering plant at four cents per pound.

Throughout the period the dressed carcasses were shipped on consignment to Baltimore where there is an established market and ready demand for human consumption. These meats were dressed and eviscerated, with the head, feet and tails chopped off. After draining any excess blood, these were packed without washing or paper lining into new bushel apple baskets. The baskets held from 50 to 52 dressed carcasses and weighed from 80.5 to 84.5 pounds net, the meats averaging 1.63 pounds each. The largest size class yielded dressed meats weighing as high as 2 pounds 1 ounce each. These meats met with a ready demand and topped the market in price, due to the large size, healthy, fat appearance and nice flavor. So large was the average size of these animals that the majority of the meats were graded as extra large or "jumbos" and brought as high as 40 cents each. In the cold climate refrigeration was found to be unnecessary and the meats reached the market in fine shape.

MANAGEMENT PRINCIPLES

Results of the present study suggest the following principles of management from the standpoint of commercial muskrat production. The area under discussion, however, was established as a migratory waterfowl refuge and is, therefore, managed primarily for that purpose.

1. A direct correlation between size and weight of muskrats and the quality and abundance of food present was found. Rank stands of "blue flag or Cooper's" cattail, *Typha glauca*, produced muskrats of largest size and finest quality. An adequate supply of this cattail should, therefore, be maintained. The submergent coontail, *Ceratophyllum demersum*, which takes over "eaten-out" pool areas, is a poor substitute and produces an inferior, smaller muskrat.

2. Water levels conducive to best growth of cattail should be maintained, where possible.

3. Sufficient muskrats must be harvested annually in order to prevent serious "eat-outs" through an overpopulation of muskrats. When open water areas are desired for certain waterfowl food plants and for migratory ducks these can often be brought about by controlled muskrat "eat-outs," through manipulating the intensity of trapping.

4. As the first 6 weeks of trapping was productive of over two-thirds of the entire crop, an "all out" effort must be concentrated during that period in order to obtain trapping unit quota limits, the latter set high enough to insure against any possibility of undesired "eat-outs."

SUMMARY

1. Over a 6-year study period, 31,867 muskrats, *Ondatra z. zibethicus*, were trapped on the Montezuma National Wildlife Refuge, Seneca Falls, N.Y. from 1943–1948. The peak year (1945) yielded 7,988 of these. 14,911 males and 15,001 females were brought in by the trappers in satisfactory condition for accurate sexing. Such a ratio, approaching 50:50, is in marked contrast to that reported by the writer and others previously for the same widely distributed race, and for a similar 5-year study of *Ondatra z. macrodon* in Maryland which showed a preponderance of 57 per cent males.

The excess of males over females generally increased each bi-weekly period as the season progressed for the first 3 years of this study and then the reverse occurred. During the last weeks of each trapping season more males than females were taken.

2. The greatest contributing factor to the accelerated, continuous growth, huge pelt size, record weights, and the fat condition of muskrats on this refuge was the abundant supply of "blue flag" cattail, *Typha glauca*, especially the dormant young green shoots or growing points beneath the ice.

3. Ideal food and water conditions existed over most of the Refuge acreage in 1944. This, together with the unusually large numbers of old individuals that had been attracted from outside drought areas, and the fact that it was the first year of intensive trapping, account for the record size and weights obtained that year. Maximum individual weights were: male 5 pounds 4 ounces (2,381 g.); and female—5 pounds (2,268 g.). The mean for all animals was 3 pounds 8 ounces (1,588 g.). As the older individuals were caught and the trapping regulated, the average weights gradually declined as had been expected. The low point was reached in 1948 when males averaged 2 pounds 15.7 ounces (1,351.7 g.), females 2 pounds 11.8 ounces (1,242.8 g.), and combined sexes only 2 pounds 13.6 ounces (1,292.7 g.). It was thought, however, that disease might have become a factor in 1948 as several trappers reported finding dead muskrats uninjured inside of feeding huts.

4. Due to difficult trapping conditions and overpopulation, "eat-outs" of cattail occurred on some areas and the remaining muskrats on these sites were forced to sustain themselves largely on the dense, submerged growth of coontail that soon took over.

5. There has always been a distinct sexual difference in weights, males averaging approximately 4 ounces or 13 per cent heavier than the females.

6. With the exception of the 1945 season, from 46 to 65 per cent of the catch each year occurred during January (50 per cent average, 1944–1948). An average of 31 per cent of the crop was taken in February at which time the pelts were in excellent, prime condition and maximum size.

7. A brief discussion is given of methods of trapping and harvesting the annual fur crop under varying conditions and preparation of the pelts and meats for marketing.

LITERATURE CITED

DOZIER, HERBERT L. 1945. Sex ratio and weights of muskrats from the Montezuma National Wildlife Refuge. Jour. Wildl. Mgt., **9**: 232–237.

———. 1948. Estimating muskrat populations by house counts. Trans. N. Am. Wildlife Conf., **13**: 372–392.

DOZIER, HERBERT L. and ROBERT W. ALLEN. 1942. Color, sex ratios, and weights of Maryland muskrats, I. Jour. Wildl. Mgt., **6**: 294–300.

DOZIER, HERBERT L., MERLE H. MARKLEY, and LEONARD M. LLEWELLYN. 1948. Muskrat investigations on the Blackwater National Wildlife Refuge, Maryland, 1941–1945. Jour. Wildl. Mgt., **12**: 177–190.

HEIT, WILLIAM S. 1949. Muskrat weights and sex ratio in the Riverbend Marshes of Wayne County, New York. Journ. Mammalogy, **30**: 122–124.

HOTCHKISS, NEIL and HERBERT L. DOZIER. 1949. Taxonomy and distribution of N. American cat-tails. The Amer. Midland Nat., **41**: 237–254.

JOHNSON, CHARLES E. 1925. The muskrat in New York. Roosevelt Wildl. Bul., **2**: 193–320.

SOME PRACTICAL CONSIDERATIONS IN THE USE OF ROTENONE IN FISHERIES RESEARCH[1]

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Although rotenone-containing compounds have been used in the eradication of fish populations since 1934 (Krumholz 1948a), it is only recently that research workers have been critical of the interpretation of the data on fish populations that stemmed from such studies. Ball (1948); Brown and Ball (1943a); Carbine and Applegate (1948); Carlander and Lewis (1948); Krumholz (1944); and others have shown that the entire fish population of a lake is seldom, if ever, completely recovered following the treatment of its waters with rotenone. Further, such terms as fish production, carrying capacity, standing crop, and others have been used synonymously in describing such populations. Clarke (1946) and Krumholz (1948b) have attempted to clarify such terminology for use in fishery work.

There are many obstacles that confront the biologist who undertakes to annihilate and analyze the fish population of any body of water in nature. Some of the difficulties that are encountered are discussed below, based largely on our own personal experiences in the field over a period of years.

Toxicity of the Rotenone-containing Preparation

The toxicity or potency of the rotenone-containing preparation is of primary importance. Several compounds are now available, such as powdered derris root, powdered cubé or powdered timbo, that contain various percentages of rotenone as the active ingredient. Those powders are the old standbys and powdered derris root was the first one used in fish management. Other preparations such as emulsifiable rotenone and *Fishtox* have come on to the market only recently.

Of the dry preparations, it has been our experience that powdered derris root (5% rotenone) as obtained from S. B. Penick and Co. is the most dependable of the powders. We have not used the derris powders of higher or lower rotenone content but can see no reason why they shouldn't be as dependable. Powdered derris root will retain its toxicity over long periods of time if kept in a cool, dry place. We have used that material after it had been stored for four years in the upstairs storeroom at one of our state fish hatcheries. At the end of that period tests showed that the powder was still lethal to yearling bluegills (*Lepomis macrochirus*) in concentrations of 0.5 ppm. Contrariwise, we have used powdered cubé that, even though it was used shortly after being received from the company, did not have sufficient potency to kill any but the most feeble

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fishes. On another occasion it apparently was as good as derris. Personal communications from other workers who used cubé indicate that they have had similar experiences. Still other workers such as Vestal (1942b) and Wales (1947) in California have used cubé with satisfactory results. In our experience, however, powdered derris root is more dependable. We have not taken the opportunity to use powdered timbo but other biologists (Vestal 1942a; Wales 1942) have found it as satisfactory as derris.

The task of mixing the powder with water into a paste suitable for dispersal is a tedious and oftentimes uncomfortable one. The dust tends to irritate the respiratory passages and often leaves the worker with a dull headache. The mixing may be facilitated with a small rotary-type concrete mixer if such an additional expense is warranted. Brown and Ball (1943b) used an outboard motor to stir the powder and water into a thick suspension before applying it to Third Sister Lake, Michigan, but such a procedure would obviously be hard on the motor as the insoluble derris mixture would circulate through the motor's cooling system and tend to clog it. If the mixture of powdered rotenone is to be applied by means of a sprayer, it is imperative that all the lumps are either broken up or removed by screening. Much valuable time can be lost if the sprayer becomes plugged.

Emulsifiable rotenone (5% rotenone) in alkylated naphthalene, as obtained from S. B. Penick and Co. has proved very satisfactory in the elimination of fish populations from small ponds in southern Indiana. We have used it in four such studies and the ease in handling, the lack of irritation to the respiratory passages, and the facility of dispersal combine to make it perhaps the ideal form of rotenone for such work. The emulsion formed when the emulsifiable rotenone is placed in water is long lasting; four drops in a pint of water imparted a milky color to the water that lasted more than 10 days. Studies have shown that an even dispersal of rotenone over the water is much more easily obtained by using the emulsifiable form than the powdered preparations. The emulsified phase is such that it settles and disperses throughout the lake of its own accord. S. B. Penick and Co. states that although 0.5 ppm. of emulsifiable rotenone is recommended for killing the fish in a body of water, 0.25 ppm. would undoubtedly give a complete kill in many lakes.

Fishtox, a special preparation containing rotenone, has been given considerable publicity by its manufacturers (Standard Supply Distributors, Wenatchee, Washington) during the past several years. We have tried it in the poisoning of two small ponds in Indiana. The first pond, about 0.5 acre in extent with a maximum depth of 6 feet, was located in Greene County near Linton. For that pond, we opened the container of Fishtox, removed 10 pounds of the contents without disturbing the remainder and resealed the can immediately. The Fishtox was mixed with water and applied to the surface of the lake by pouring it from a 10-gallon milk can alongside a boat propelled by an outboard motor. All checks following the application indicated a complete kill of the fish population which consisted of green sunfish (*Lepomis cyanellus*) and black bullheads

(*Ameiurus m. melas*). The remaining Fishtox was taken back to the laboratory and kept in a dark, dry room. A month later we used the remaining 30 pounds of Fishtox in an attempt to eradicate the fish population from a 1.4 acre pond (maximum depth, 10 feet) in Vanderburg County near Evansville. When we reopened the can it was noticed that the upper third of the Fishtox had turned a reddish-brown color; the lower two-thirds having remained its original color. Unfortunately, the Fishtox apparently lost much of its potency during the interval between the treatment of the two ponds. We applied the remaining 30 pounds to the second pond and obtained only an insignificant kill. One seine haul with a 30-foot bag seine 6 hours after application of the Fishtox yielded 77 green sunfish 3–6 inches long and two largemouth bass (*Micropterus salmoides*) 7 inches in length, that were apparently unaffected by the treatment. The remainder of the fish population was killed with powdered derris root (5% rotenone).

Following the above mentioned experience with Fishtox we have hesitated to use it again inasmuch as most of our eradication work is on small ponds that should require only part of the contents of one can. If the entire contents of a can of Fishtox is used in one treatment our experience indicates that it is as effective as other rotenone-containing preparations.

DISTRIBUTION OF ROTENONE PREPARATION

The usual field procedures for the distribution of rotenone preparations have been adequately described by Eschmeyer (1937), M'Gonigle and Smith (1938), Krumholz (1948a) and others. Ball (1948), following the lead of Krumholz and Shetter (Krumholz 1948a), used a centrifugal pump for forcing the rotenone into the deeper parts of Ford Lake, Michigan. Wales (1947) used a modification of the siphon described by Krumholz (1944) to get the rotenone into the deeper reaches of Castle Lake, California.

In June 1949 we tried a variation of an older method of getting rotenone into deep water of a pond (maximum depth 10 feet) with considerable success. About two hours after a third daily application of emulsifiable rotenone was made to the surface of the pond we mixed a thick paste of powdered derris root (5% rotenone) and broadcast it from a boat and the shore over the deepest parts of the pond. As the blobs of paste struck the water they scattered and settled gradually toward the bottom. Within 30 minutes after that application several large black bullheads (up to two pounds in weight) came to the surface in distress. The appearance of those distressed bullheads so long after the first application of emulsifiable rotenone indicated that the material applied to the surface was not reaching the deeper water and that the later application of the paste did. It may be, however, that the emulsifiable rotenone did reach the deeper water but the bullheads were "mudded in" because of the disturbance caused by the outboard motor during the application.

More recently, Siegler and Pillsbury (1949) have advocated the spraying of large bodies of water with rotenone from the air. Their particular problem was in applying the chemical to extensive mud flats and pools left near the perimeter of large lakes that had been

lowered previous to the treatment. Further, they described a power mixer that cut the time required for mixing the powder with water to one-seventh that required by old manual method. Both of these innovations have proved themselves to be great time savers. In addition, S. B. Penick and Company has advocated the use of airplanes or helicopters in the distribution of rotenone over large bodies of water.

SUSCEPTIBILITY OF FISHES TO ROTENONE

It is common knowledge that rotenone is more toxic to some kinds of fish than to others (Wray 1892; Harris 1925; Leonard 1939; Smith 1940). The trouts are more susceptible than sunfishes which in turn are less resistant than bullheads.

The complete eradication of black bullheads from farm ponds in Indiana is a difficult task. Oftentimes that species is introduced because the farmer wants "catfish" in the pond. Following that introduction, the bullheads generally become so numerous that they tend to crowd out nearly every other species present.

In an earlier paper (Krumholz 1948a) it was mentioned that, during July 1946, we treated a pond of 1.4 acres in extent in Knox County, Indiana, with sufficient powdered derris root to give a concentration of 1.0–1.5 ppm. Following that treatment we picked up 3,543 black bullheads that weighed 356 pounds (260 pounds per acre). Following the removal of such a crop of bullheads we assumed that we had killed them all and later that fall we stocked the pond with 12 largemouth bass (1½–3 pounds). The next spring the owner informed us that he saw several schools of small bullheads in the pond. Inasmuch as we had obligated ourselves to rid the pond of that species we treated the pond with sufficient powdered derris root (5% rotenone) to give a concentration of 1 ppm. on August 18, 1947. Then on August 20, in order to kill any fish which might have escaped the first treatment we gave the pond a second similar dose. Following those treatments we picked up a total of 6,621 black bullheads of which only 6 were large enough to have been survivors from the treatment of the previous year. Although the numbers were greater than those of the 1946 study, the total weight was only 276 pounds (201 pounds per acre). Again, assuming that we were rid of the bullheads, we stocked the pond with hybrid sunfish (*Lepomis macrochirus* x *L. microlophus*).

The next spring (1948) we were again informed that there were schools of small bullheads in the pond. We planned to treat the pond again that summer but circumstances led us to postpone the treatment until 1949. On June 17, 1949, we treated the pond with 1½ gallons of emulsifiable rotenone over the surface plus five pounds of powdered derris root (5% rotenone) scattered in the shallow areas around the shore. That amount was sufficient to give a concentration of 1.5 ppm. That same treatment was repeated on June 18 and again on June 19. Two hours following the treatment of June 19 we broadcast a paste of powdered derris root and water over the deeper water as mentioned earlier. We hoped this last application might kill any fish that remained near the pond bottom. It

brought out a total of 11 bullheads. During and following the 1949 treatment we picked up only five bullheads that were large enough to have been present in the pond in August 1947. In addition we picked up over 52,000 small bullheads. The total weight of all bullheads was 428 pounds (312 pounds per acre). Subsequent tests by seining and trapping have revealed no fish but it would be relatively easy to miss a few fish in seining a pond 1.4 acres in extent. We have never experienced such difficulty in eradicating populations of any other species.

RECOVERY OF FISH FOLLOWING TREATMENT WITH ROTENONE

The recovery of the complete fish population from any body of water following its treatment with rotenone, or any other toxic material for that matter, is virtually impossible. Brown and Ball (1943a, 1943b) noticed that when they poisoned Third Sister Lake in Michigan all the fish that were killed did not come to the surface and hence were not recovered. Krumholz (1944) estimated that 86 per cent of the marked largemouth bass, bluegills, pumpkinseeds (*L. gibbosus*), and bluegill×pumpkinseed hybrids were recovered following the treatment of the north basin of Twin Lake, Oscoda County, Michigan. Carlander and Lewis (1948) following the poisoning of a small pond in Marion County, Iowa, recovered only 38 per cent of the bluegills, 14 per cent of the white crappies (*Pomoxis annularis*), 33 per cent of the largemouth bass, 80 per cent of the black bullheads, and 91 per cent of the golden shiners (*Notemigonus crysoleucas*) that had been marked prior to the poisoning. All together they recovered about 60 per cent of the marked fish. Ball (1948) marked 240 bluegills and 210 brook trout (*Salvelinus fontinalis*), by clipping the dorsal fin, prior to the treatment of Ford Lake, Otsego County, Michigan. Following the treatment of the lake with powdered derris root, Ball recovered 145 marked bluegills (59 per cent) and 94 marked trout (45 per cent) for a total of 239 fish (52 per cent). However, Ball stated that " . . . The last live bluegill was seen on the morning of August 29, 2½ days after the poisoning; the last fish seen alive was a mudminnow (*Umbra limi*) on the afternoon of the same day. Both fish were in a dying condition when found . . . ". Although a 32-hour set with an experimental gill net August 29–30 yielded no fish, the presence of live fish, even though dying, so long after treatment usually indicates an incomplete kill. Our experience has been that the presence of living fish in a treated lake more than about 36 hours after treatment is a good indication that the entire fish population has not been killed. Although they had no means of checking their accuracy, Carbine and Applegate (1948) believed that they recovered nearly all fish one year old or older after poisoning Deep Lake, Michigan. They continued to visit the lake for 17 days following the poisoning to assure as complete a recovery as possible.

In an attempt to obtain further information on the completeness of recovery of fish populations following treatment with rotenone, we poisoned a pond on the A. L. Lutz farm, Perry Township, Vanderburgh County, Indiana. That pond was 1.4 acres in extent

and had a maximum depth of 10.5 feet. During the morning of June 7, 1949, we collected 501 green sunfish and 31 largemouth bass by seining, measured each fish, marked them by excising the left pectoral fin, and returned them to the pond. All of the largemouth bass that were marked were of the 1947 year class, whereas the green sunfish that were marked represented nearly all available age groups. Immediately afterward (10:30–11:30 a.m. June 7, 1949) we treated the pond with 30 pounds of Fishtox. Seinehauls late that same afternoon revealed that much of the fish population was apparently unaffected by the treatment. Accordingly, we treated the pond a second time (June 8, 3–4 p.m.), using 20 pounds of powdered derris root (5% rotenone), enough to assure a complete kill.

The data for all fish recovered each day were kept separate. All the dead fish that could be found around the pond edges and on the surface were picked up by the end of each day and all measurements and other pertinent data recorded. As soon as those fish had been handled they were disposed of. Thus, the first evening and each succeeding evening the pond surface and edges were completely cleared of dead fish. Also, the records of any fish killed during the first treatment were kept separate, so far as possible, from those killed by the second treatment. For instance, fish that had obviously been dead only a short period of time when recovered on the morning of June 9 were kept separate from those that had been dead for a day or two. Those "fresh" fish picked up on the morning of June 9 were presumed to have been killed by the second treatment; those that had been dead for a day or two, by the first. We continued to pick up any dead fish that could be found until 6 p.m., June 16, a period of 10 days after the first poisoning. Such an extended period for retrieving poisoned fish gives ample time for the great majority of such fish that may have sunk to the bottom when they died a chance to bloat and rise to the surface. The length of time for such bloating largely depends on the temperature of the water. Any extension of that 10-day period would have been to to no avail as the fish picked up on June 16 were in such an advanced stage of decomposition that they readily fell apart when lifted from the water.

As the dead fish were brought in they were sorted to species and examined for excised fins. All marked fish recovered were measured and weighed. In addition, random samples of green sunfish and largemouth bass were weighed and measured each day. Thus we had a daily, running account of the numbers, lengths, and weights of all the marked fish recovered as well as similar data for random samples of the unmarked individuals as well. All together, we recovered 456 (91.0 per cent) of the green sunfish and 27 (87.1 per cent) of the largemouth bass—a total of 483 (90.8 per cent) of the 532 fish that had been marked on June 7 prior to the poisoning. Inasmuch as the dead fish were picked up for at least eight days following the treatment of the pond with rotenone, such a high percentage of recovery is, perhaps, unusual. Ball (1948) spent six days trying to recover any dead fish and Carlander and Lewis (1948) spent only five. Although Krumholz (1944) also spent 10 days recovering dead fish and succeeded in retrieving

86 per cent of the marked fish, his results may have been affected by the facts that some of those fish were marked six weeks prior to the poisoning, and some may have escaped into the other basin of the lake prior to the erection of the barrier between the two basins.

tion between the percentages of marked and unmarked fish recovered daily. Such a correlation indicates that the marked fish died and were picked up at about the same rates as the unmarked ones. For instance, of the 4,221 green sunfish recovered 456 (10.8 per cent) were marked and if the fish were picked

TABLE 1.—NUMBERS OF LARGEMOUTH BASS, GREEN SUNFISH AND THE TWO SPECIES COMBINED, BOTH MARKED AND UNMARKED, TOGETHER WITH THE PERCENTAGE OF MARKED FISH RECOVERED AND THE PERCENTAGE OF RECOVERED FISH, BOTH MARKED AND UNMARKED, PICKED UP EACH DAY FOLLOWING THE TREATMENT WITH ROTENONE. THE FISH LISTED AS RECOVERED THROUGH THE MORNING OF JUNE 9 ARE FROM THE FIRST POISONING, THOSE AFTER THAT ARE FROM THE SECOND

		Date, 1949								
		6/7	6/8	6/9 a.m.	6/9 p.m.	6/10	6/11	6/13	6/15	6/16	Total
		Largemouth black bass									
Marked fish	No. recovered	11	9	7	—	—	—	—	—	—	27
	Pct. fish recovered	35.5	29.0	22.6	—	—	—	—	—	—	87.1
	Pct. recovered fish	40.8	33.3	25.9	—	—	—	—	—	—	100.0
Unmarked fish	No. recovered	280	126	17	—	12	—	2	—	—	437
	Pct. recovered fish	64.1	28.8	3.9	—	2.7	—	0.5	—	—	100.0
All fish	No. recovered	291	135	24	—	12	—	2	—	—	464
	Pct. recovered fish	62.7	29.1	5.2	—	2.6	—	0.4	—	—	100.0
		Green Sunfish									
Marked fish	No. recovered	78	95	4	174	77	13	12	2	1	456
	Pct. fish recovered	15.6	19.0	0.8	34.7	15.3	2.6	2.4	0.4	0.2	91.0
	Pct. recovered fish	17.1	20.8	0.9	38.2	16.9	2.9	2.6	0.4	0.2	100.0
Unmarked fish	No. recovered	606	1,114	84	1,511	318	42	60	20	10	3,765
	Pct. recovered fish	16.1	29.6	2.2	40.1	8.5	1.1	1.6	0.5	0.3	100.0
All fish	No. recovered	684	1,209	88	1,685	395	55	72	22	11	4,221
	Pct. recovered fish	16.2	28.6	2.1	39.9	9.4	1.3	1.7	0.5	0.3	100.0
		Largemouth bass and Green sunfish									
Marked fish	No. recovered	89	104	11	174	77	13	12	2	1	483
	Pct. fish recovered	16.7	19.5	2.1	32.7	14.5	2.4	2.3	0.4	0.2	90.8
	Pct. recovered fish	18.4	21.5	2.3	36.0	16.0	2.7	2.5	0.4	0.2	100.0
Unmarked fish	No. recovered	886	1,240	101	1,511	330	42	62	20	10	4,202
	Pct. recovered fish	21.1	29.5	2.4	36.0	7.8	1.0	1.5	0.5	0.2	100.0
All fish	No. recovered	975	1,344	112	1,685	407	55	74	22	11	4,685
	Pct. recovered fish	20.8	28.6	2.4	36.0	8.7	1.2	1.6	0.5	0.2	100.0

The day to day record of the numbers of marked and unmarked fish recovered from Lutz' pond is given in Table 1. In addition, the percentage of the total number of fish marked prior to the poisoning that were recovered each day as well as the percentage of the number of recovered marked fish are given. Particularly among the green sunfish, there is a fairly good correla-

up at the same rate, 10.8 per cent of all fish picked up on any day should have been marked. Such percentages ranged from 7.9 on June 8 to 23.6 on June 11. However, on June 9 when more fish were picked up than on any other day the percentage of marked fish in the total was 10.8. On June 8, when the next largest number of fish was recovered, only 7.9 per cent were marked. It

may be that the recently marked fish took cover in the deepest part of the pond following the marking procedure and were not brought out until the second treatment. Such a conclusion is also suggested by the increased abundance of marked fish on June 10, 11, and 13 when 19.5, 23.6, and 16.7 per cent respectively of the recovered fish were marked.

Another important factor that has a direct bearing on the recovery of fish following rotenone poisoning is the relative abundance of brush, aquatic plants and debris in the shallow water. If the shoreline and shallow water are clear of such obstructions the total number and weight of fish that can be readily recovered will usually be considerably higher than in ponds with woody or bushy shorelines. In 1946 and 1947 we treated 10 small ponds in southern Indiana with rotenone. Those ponds ranged from 0.25 to 3.90 acres in extent. In half those ponds the shorelines and shallow waters were free of brush, cattails, and other obstacles that hampered the picking up of dead fish. In the other five ponds there were such obstacles as cattails along from 60–80 per cent of the shoreline or there were willows or other brushy plants that hampered our efforts to recover the fish. Some of the ponds with clear shorelines were in the same kind of soil and watersheds as those with brushy shorelines. However, when we tabulated the data from those 10 ponds and separated them into categories on the basis of clear or brushy shoreline alone we found that the five ponds with clear shorelines (total area 3.54 acres) yielded an average of 465.3 pounds of fish per acre whereas from those four with brushy shorelines (total area 3.30 acres) we recovered an average of only 242.3 pounds per acre. The tenth pond, which we classed as intermediate had an area of 3.90 acres and we recovered a total of 387.3 pounds per acre. Furthermore, there was no overlapping in total recovered weights per acre in any of the three categories (Table 2).

TABLE 2.—RECOVERED WEIGHTS OF FISHES FROM 10 PONDS IN INDIANA FOLLOWING TREATMENT WITH ROTENONE-CONTAINING COMPOUNDS. THOSE DATA HAVE BEEN SEPARATED INTO CATEGORIES OF CLEAR, INTERMEDIATE, OR BRUSHY, DEPENDING ON THE ABUNDANCE OF SUBMERGED OR EMERGENT VEGETATION ALONG THE EDGES OF THE PONDS, TOGETHER WITH THE AREA OF EACH POND, THE TOTAL POUNDS OF FISH RECOVERED AND THE POUNDS OF RECOVERED FISH PER ACRE

	Clear					Intermediate	Brushy			
Pond number	1	2	3	4	5	6	7	8	9	10
Area, acres	1.37	0.61	0.68	0.63	0.25	3.90	0.73	1.41	0.80	0.36
Total weight recovered, pounds	627.7	312.0	339.6	251.1	116.7	1,355.5	246.8	281.1	216.7	55.1
Recovered weight, pounds per acre	458.2	511.5	499.4	398.6	466.6	387.3	338.1	199.3	270.8	153.1

CHANGES IN WEIGHTS OF FISH AFTER DEATH

The usual basis for indicating the standing crop of fish of a body of water after treatment with rotenone is the weight of the recovered fish in pounds per acre. One of the common procedures following such a poisoning is the con-

tinued picking up, counting, and weighing of all fish found for any selected number of days. Such data are usually thought to constitute accurate information regarding the total recovered population. Even though the accuracy of the numbers of fish counted cannot be questioned in the instances where actual counts are made, it is generally agreed that the total weight of any fish will change as it decomposes. Such changes through decomposition may cause either an increase or a decrease in weight due to differences in osmotic pressures or other factors.

When we poisoned the pond on the A. L. Lutz farm on June 7, 1949, as mentioned earlier, we kept a running day-to-day record of the individual lengths and weights of samples of the green sunfish and largemouth bass recovered. The data for green sunfish, of which there were larger samples measured, when arranged in length groups of five millimeters indicate that there is an average loss of 9.3 per cent of body weight between the first and second days after death and a loss of 11.0 per cent between the second and third days, the overall loss between the first and third days being 18.8 per cent (Table 3). Those average losses were computed from the decreases for all length groups, each group being weighted as the harmonic mean of the numbers of fish picked up on the days in question. The data for the lengths and average weights of those three categories of fish are shown graphically in Figure 1. Here it is obvious that in making an accurate estimate of the live weight of the fish recovered there would have to be an upward adjustment in the weight of all fish picked up after the first day. Those picked up on the second day would have been about

TABLE 3.—NUMBERS AND AVERAGE WEIGHTS OF GREEN SUNFISH, IN FIVE-MILLIMETER LENGTH GROUPS, RECOVERED ON THE FIRST, SECOND, AND THIRD DAYS FOLLOWING POISONING WITH ROTENONE, TOGETHER WITH THE PERCENTAGE LOSS IN WEIGHT BETWEEN THE FIRST AND SECOND AND SECOND AND THIRD DAYS OF FISH IN EACH LENGTH GROUP, AND THE AVERAGE LOSS FOR ALL GROUPS FOR EACH PERIOD

Fork Length, Millimeters	First Day		Percentage Loss in Av. Wt., 1st to 2nd Day	Second Day		Percentage Loss in Av. Wt., 2nd to 3rd Day	Third Day	
	No. of Fish	Av. Wt., Grams		No. of Fish	Av. Wt., Grams		No. of Fish	Av. Wt., Grams
75	5	9.0	16.7	2	7.5	6.7	1	7
80	12	10.8	9.3	15	9.8	—	—	—
85	46	12.6	11.9	29	11.1	0.9	1	11
90	70	14.0	10.7	47	12.5	17.6	7	10.3
95	129	16.5	10.9	49	14.7	8.8	13	13.4
100	73	19.2	6.8	28	17.9	17.3	16	14.8
105	60	22.1	7.7	18	20.4	7.8	13	18.8
110	40	26.1	8.4	19	23.9	8.8	8	21.8
115	31	31.0	9.4	14	28.1	9.3	8	25.5
120	15	33.7	5.6	10	31.8	4.7	4	30.3
125	24	38.0	6.1	13	35.7	13.7	5	30.8
130	5	44.2	10.4	10	39.6	2.8	2	38.5
135	6	49.5	4.0	10	47.5	—	—	—
140	9	56.4	8.7	6	51.5	—	—	—
Average loss in weight			9.3			11.0		

9 per cent underweight and those picked up the third day about 19 per cent underweight.

Among the largemouth bass picked up from the same pond on the same days the change in weight following death is considerably different. The numbers of fish, although not actually as large as those for the green sunfish, are probably sufficiently representative. When the data for the bass were treated similarly as those for the green sunfish, we found that the bass actually gained 6.0 per cent in weight during the first day after death, remained at that weight for a day, and then lost weight (Table 4). By the fourth day after death they had lost a total of only 1.8 per cent of their fresh weight. The reason for the gain in weight by the bass concomitant with a loss in the green sunfish is not obvious. The fish were in the same water and were picked up at the same time. Perhaps some post mortem physiological or chemical changes may be held accountable.

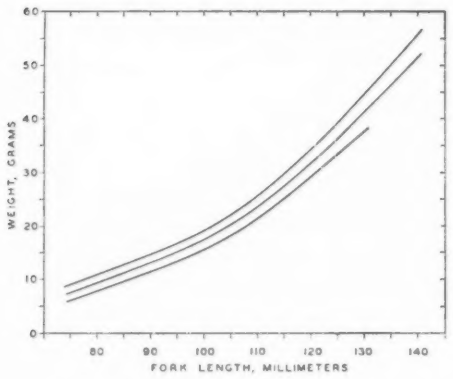

FIG. 1. Length weight relationships of green sunfish of the same population taken on the first (upper curve), second (middle curve) and third (lower curve) days after death. Data from Table 3.

In another pond we found that the average weight of largemouth bass fingerlings decreased 11.75 per cent within a day after poisoning with rotenone. Those bass were young-of-the-year fish that ranged in fork length from 50 to 90 millimeters with an average length of 62 millimeters. As the fish were brought in the day the rotenone was applied (August 18, 1947) they were weighed in lots of 100 fish each. The average weight per fish based on weights of 16 such lots was 3.15 grams. The following morning (August 19, 1947) the average weight based on

TABLE 4.—NUMBERS AND AVERAGE WEIGHTS OF LARGEMOUTH BASS, IN FIVE-MILLIMETER LENGTH GROUPS, RECOVERED ON THE FIRST, SECOND, THIRD, AND FOURTH DAYS FOLLOWING POISONING WITH ROTENONE, TOGETHER WITH THE PERCENTAGE LOSS IN WEIGHT BETWEEN SUCCESSIVE DAYS FOR FISH IN EACH LENGTH GROUP AND THE AVERAGE LOSS FOR ALL GROUPS FOR EACH PERIOD

Fork Length, Millimeters	First Day		Percentage Change in Weight, 1st to 2nd Day	Second Day		Percentage Change in Weight, 2nd to 3rd Day	Third Day		Percentage Change in Weight, 3rd to 4th Day	Fourth Day	
	No. of Fish	Av. Wt. Grams		No. of Fish	Av. Wt. Grams		No. of Fish	Av. Wt. Grams		No. of Fish	Av. Wt. Grams
135	4	32.3	+3.1	4	33.3	—	—	—	—	—	—
140	6	34.0	+6.1	18	36.2	−1.4	3	35.7	−7.6	1	33
145	32	38.9	+3.3	27	40.2	+3.5	5	41.6	−6.3	1	39
150	26	43.4	+5.3	25	45.8	+0.2	9	45.9	−8.5	1	42
155	34	48.2	+8.1	24	52.1	−1.2	4	51.5	−6.8	3	48.0
160	20	54.1	+3.9	10	56.2	—	—	—	—	2	49.0
165	15	58.4	+13.2	8	66.1	−3.9	2	63.5	−6.3	2	59.5
170	6	65.8	+6.8	8	70.3	—	—	—	—	2	66.5
Average change, weight			+6.0			+0.1			−7.0		

seven lots of 100 each had dropped to 2.84 grams, a loss of 9.85 per cent in body weight. The average weight of eight lots of 100 fish each picked up that same afternoon was 2.78 grams, indicating a further loss in weight during the period between the time of pickup in the morning and afternoon. Random samples of the length distributions of the fish picked up during the first day and the morning and afternoon of the second day showed no difference in size range or average length.

In a population of bluegill×redear sunfish hybrids that was killed with rotenone we found that an average of 7.8 per cent of the weight was lost between the first and second day following the treatment. Unfortunately, most of the recoverable population was picked up during the first two days and there were not sufficient numbers of fish recovered after that time to give adequate data for comparison.

Among fingerling black bullheads that ranged in length from 57 to 102 millimeters with an average length of 67.8 millimeters, we found an average loss of 16.77 per cent of body weight from the day of treatment (average weight 4.77 grams) to the following day (average weight 3.97 grams). Those fish were weighed in lots of 75 individuals and the size range and average length were the same each day. On another occasion we found that the loss in weight among fingerling black bullheads was negligible during the first three days but that between the third and fourth days those fish disintegrated rather rapidly. The reason for such a difference in loss in weight among black bullhead fingerlings may well be due to differences in temperature. On the first-mentioned occasion the surface water temperature on the day of treatment (August 18, 1947) was 88°F., whereas on the second occasion (June 20, 1949) the surface water temperature was only 68° F.

PREDATION BY OTHER FISHES

Almost everyone who has attended a rotenone treatment of a lake has noticed that the larger fishes picked up oftentimes have smaller ones in their gullets. The small fish in their dying gyrations are an easy and apparently attractive prey for the larger fish which in turn seldom live to enjoy their easily won meal. If large numbers of small fish are eaten in that manner the total weight of the predatory species will be enhanced at the expense of the weight and numbers of the species eaten. Perhaps the commonest offender along that line is the largemouth bass and unless each such bass is examined carefully the number of young fish eaten cannot be determined.

However, bass are not the only fish that eat large numbers of small fishes on such occasions. In one instance, when we poisoned the Williams Pond in 1947, we found that the black bullheads had eaten many of the fingerling bass as they died. Upon opening 100 bullheads at random, we found that they had taken in a total of 72 fingerling bass. Of those 100 bullheads 44 had no bass in them, 41 contained 1 bass, 12 contained two bass each and 2 contained 3 each. The total weight of the 100 bullheads before the bass were removed was 5,296 grams. The 72 bass, upon removal, weighed 206 grams. Thus, the actual weight of the bullheads was greater than it should have been and

that added weight was gained at the expense of the bass.

LITERATURE CITED

BALL, ROBERT C. 1948. Recovery of marked fish following a second poisoning of the population in Ford Lake, Michigan. Trans. Am. Fish Soc., **75**(1945): 36–42.

BROWN, C. J. D., and ROBERT C. BALL. 1943a. A fish population study of Third Sister Lake. Trans. Am. Fish Soc., **72** (1942): 177–186.

———. 1943b. An experiment in the use of derris root (rotenone) on the fish and fish-food organisms of Third Sister Lake. Trans. Am. Fish Soc., **72**(1942): 267–284.

CARBINE, W. F. and VERNON C. APPLEGATE. 1948. The fish population of Deep Lake, Michigan. Trans. Am. Fish. Soc., **75** (1945): 200–227.

CARLANDER, KENNETH D., and WILLIAM M. LEWIS. 1948. Some precautions in estimating fish populations. Prog. Fish-Cult., **10**(3): 134–137.

CLARKE, GEORGE L. 1946. Dynamics of production in a marine area. Ecol. Mono., **16**: 321–335.

ESCHMEYER, R. WILLIAM. 1937. Some characteristics of a population of stunted perch. Pap. Mich. Acad. Sci., Arts, Lett., **22**: 613–628.

HARRIS, E. L. 1925. Tuba fishing on the Perak River. Am. Foreign Service Jour., **2**: 297–299, 318.

KRUMHOLZ, LOUIS A. 1944. A check on the fin-clipping method for estimating fish populations. Pap. Mich. Acad. Sci., Arts, Lett., **29**: 281–291.

———. 1948a. The use of rotenone in fisheries research. Jour. Wildl. Mgt., **12**(3): 305–317.

———. 1948b. Variations in size and composition of fish populations in recently stocked ponds. Ecology, **29**(4): 401–414.

LEONARD, JUSTIN W. 1939. Notes on the use of derris as a fish poison. Trans. Am. Fish. Soc., **68**(1938): 269–280.

M'GONIGLE, R. H. and M. W. SMITH. 1938. Cobequid Hatchery—fish production in Second River, and a new method of disease control. Prog. Fish-Cult., **38**: 5–11.

SIEGLER, HILBERT R. and HAROLD PILLSBURY. 1949. Progress in reclamation techniques. Prog. Fish. Cult., **11**(2): 125–129.

SMITH, M. W. 1940. Copper sulphate and rotenone as fish poisons. Trans. Am. Fish. Soc., **69**(1939): 141–157.

VESTAL, ELDEN H. 1942a. Rough fish control in Gull Lake, Mono County, California. Calif. Fish and Game, **28**(1): 34–61.

———. 1942b. Reclamation with rotenone of Crystal Lake, Los Angeles County, California. Calif. Fish and Game, **28**(3): 136–142.

WALES, J. H. 1942. Carp control work in Lake Almanor, 1941. Calif. Fish and Game, **28**(1): 28–33.

———. 1947. Castle Lake trout investigation 1946 catch, and chemical removal of all fish. Calif. Fish and Game, **33**(4): 267–286.

WRAY, L., JR. 1892. On the Malayan fish poison called aker tuba, Derris elliptica. Pharm. Jour. and Trans. (ser. 3, vol. 23) **52**: 61–62.

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THE BOUNTY SYSTEM IN ONTARIO

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The payment of bounties for the destruction of animals believed to be undesirable has been considered a necessity in North America for many years. As early as 1683 a bounty was offered for the destruction of wolves in Pennsylvania (Cross, 1937a), and early in the eighteenth century a bounty was placed upon wolves in Canada. Bounty laws are, however, becoming less popular, especially in the eyes of biologists and wildlife management agents, who have made a study of their effects. Jacobsen, (1945) says, "At no time in our thirty years of direct and indirect association with predatory animal control work in the western states have we encountered any bounty payment plan which of itself has successfully brought about the reduction of predators when and where needed."

Henderson and Craig (1932) state, "The bounty system with reference to coyotes and wolves which has been tried for many years in most States is very expensive, productive of endless fraud, and fails to give general or permanent relief." Similar opinions have been expressed with reference to Ontario by Cross (1937a).

This decline in popularity of the bounty system is partially due to the fact that many authorities have expressed doubt as to whether predation is as important in the depletion of game species as was formerly supposed. Errington (1936), looks upon the carrying capacity of the habitat as a more important factor in population control. Cross (1937a) suggests that inadequate forage, and the encroachment of civilization upon the habitat are more responsible for the reduction of the Ontario deer herd than is predation. Stebler (1944) finds that of 238 deer carcasses autopsied in Michigan over the period 1932 to 1939, 13% died as a result of predation and the remainder died as a result of malnutrition, disease, accident, etc.

In addition to these considerations, many writers incline to the opinion that the animals killed and presented for bounty are merely the surplus of the predator population, and it is practically impossible to affect the breeding stock which keeps the population up. Cross (1937b) estimates that in order to kill a total number of animals that would exceed the number of young wolves reaching maturity annually in Ontario, an annual kill of 300,000 wolves would be necessary, costing the Province, at the then (1937) prevailing bounty rate, $400,000 a year. Errington, (1936) states, "Evidence suggests that prey populations could stand more predation than they ordinarily get, and seem to be self-limiting and self-adjusting in numbers. The trimming down of excess populations that must disappear anyway is incidental and should not be regarded as a threat to the nucleus, which barring drastic changes in the environment, will continue to occupy all available space and produce the usual annual surplus." This statement, made with reference

to prey species, will also apply with reference to predator species. In view of these opinions on this subject, expressed by prominent authorities in game management, it seems desirable to review the history of the bounty system in Ontario, and to evaluate its present status in the light of such information as is available.

The wolf has traditionally been considered the chief enemy of deer, and it is with special reference to the wolf that any study of the bounty system in Ontario must be undertaken. The wolf is the only animal upon which a bounty is offered in Ontario, aside from a few local or county bounties on bears and foxes. Several vivid accounts of examples of the depredations among the deer herds by wolves are given in the reports of the Special Committee on the Game Situation for Ontario of 1933. These accounts are given by game wardens, settlers and trappers. In one case, five deer were killed by one wolf in less than fifty yards distance. In another case, over fifty deer were found killed in less than a square mile. The observer believed that one wolf was responsible for most of this. Many similar incidents were reported to the Committee, and one observer stated that a full grown wolf will destroy twenty-five deer each season. The report of the Special Committee for 1911 states that each wolf destroys one or two deer each week of the year.

A study of the information available on the history of the bounty system in Ontario, reveals that as far back as 1859, a bounty of $6.00 was paid on wolves of any type or age, payable by the treasurer of the County in which the claim originated. The skin was kept for disposal by the Crown. In 1892 this was increased to $10.00, to be paid by the Provincial Government in Districts, and by the County Treasurer in Counties. In the latter case, 40% of the payment was rebated by the Provincial Government. This policy is still adhered to.

In 1900, this was increased to $15.00, and in 1916 the bounty on brush wolves (*Canis latrans*) was reduced to $5.00, that on timber wolves (*Canis lupus*) remaining at $15.00. In 1918, $20.00 was paid on timber wolf pelts, the bounty of brush wolves remaining at $5.00. In 1920, the bounty on brush wolves was raised to $20.00 and that on timber wolves to $40.00. In this year also, $5.00 was paid on pup pelts. This price on pups was increased to $15.00 in 1949. The policy of returning the pelts to the claimant was also adopted in 1924, when the bounty on timber wolves was reduced to $15.00 and that on brush wolves to $10.00. In 1925, the payment on brush wolves was raised to $15.00. In 1930, the payment on adults was raised to $25.00 in southern Ontario, and $10.00 was added to the $15.00 payable for claims originating in northern Ontario if the wolf was killed within twenty-five miles of an agricultural settlement. This twenty-five mile provision was removed in 1931, and $25.00 was payable on all adults. In 1933, this was reduced to $15.00, and in 1941 again raised to $25.00. The wolf bounty has remained at this figure since then.

Examination of the figures in Table 1 will give an indication of the enormous sums of money that have been expended in Ontario since 1905 in an endeavour to control the wolf. The purpose of this

TABLE 1. SHOWING AMOUNTS PAID IN BOUNTIES ANNUALLY IN ONTARIO SINCE 1905

Year	Total Payments Including Administrative Expenses, Year Ending Oct. 31	Revenue from Sale of Pelts	No. of Applications on Which Bounty Paid
1905	$ 5,406.00		
1906	8,367.00		Information not available
1907	9,471.00		
1908	16,896.00	Information not available	
1909	18,135.00		
1910	14,951.00		
1911	8,663.00		
1912	8,872.00		
1913	8,277.00		
1914	8,109.00		
1915	6,477.00		
1916	6,543.00		
1917	8,086.00	$ 2,780.75	
1918	5,052.00	2,734.00	
1919	7,587.00	2,054.23	
1920	4,400.00	1,760.00	
1921	36,955.00	3,644.00	
1922	59,794.00	14,086.34	
1923	53,217.00	16,198.77	
1924	55,951.00	12,079.50	
1925	24,645.15	170.00	1,918
1926	51,994.42		3,819
1927	82,970.07		5,514
1928	91,297.27		6,173
1929	53,495.13		3,588
1930	38,074.77		2,551
1931	55,873.80	Pelts returned to claimant	2,751
1932	68,481.35		2,872
1933	53,433.88		2,384
1934	27,080.65		1,859
Period ending Mar. 31			
1936	42,399.89		2,905
1937	33,360.63		2,318
1938	27,474.24		1,889
1939	25,357.00		1,795
1940	25,058.12		1,743
1941	16,477.43		1,146
1942	40,593.77	Nov. 1942 to June 1945, pelts turned over Seaman's Fur Vest War Project	1,813
1943	30,606.62		1,464
1944	46,545.75		2,065
1945	45,993.58		1,998
1946	44,999.87		2,073
1947	59,275.18		2,664
1948	54,923.38		2,540

The information given in this table is taken from the records of the Department of Game and Fisheries for Ontario. Up to 1924, bounty payments were disbursed through the Ontario Department of Finance, and the records of number of applications for the period prior to 1925 are not available.

control is protection of the deer herds of Ontario, in order to furnish sport for hunters, (Special Committee Report, 1933), and protection of domestic animals in agricultural districts.

The extent to which this control has been effective, and the effect on the deer herd of such control as has been exercised, are both difficult to estimate, because factual information on Ontario wildlife is scarce, and of fairly recent compilation. The Special Committee on

the Game Situation in Ontario states in its Report (1933) that "from a conservation standpoint, there is the need of a great deal of fundamental information touching the composition of our deer herd compared with the deer herds across the border where more data than we have have been compiled concerning conditions of winter yarding, proportion of sexes, average age, etc." "There is not, and never has been attempted, a census of Ontario hunting districts. In the majority of the States the practice is adhered to of publishing the annual deer kill. From this, a rough census could be figured." A similar "rough census" is all that is available as an indication of wolf populations in Ontario and it appears that a project involving such large expenditures of money should be worthy of investigation.

Just how far the figures of annual kill with reference to wolves may be taken as an index of wolf population density is open to question. Gerstell (1937) points out that the annual kill is influenced both by economic conditions, such as national disturbances which take the trappers away, fur prices, etc., and by climatic conditions, such as heavy snowfall which may make the animals easier to take. However, it is logical to assume that a heavy population will force some of the animals into less favourable ways of life which will enable them to be caught more easily. Thus, speaking very broadly, annual kill is an indication of the population density.

If this be so, a study of Table 2 which shows the number of pelts taken per year of each species, and pups of both species, reveals several interesting points.

Examination of Table 2 with reference to timber wolf pelts shows that, with minor fluctuations, the timber wolf take per annum for the last twenty years has remained surprisingly constant. This would appear to indicate that an annual take of between 1,000 and 1,500 timber wolves has not sensibly affected the breeding stock, because this take off has been maintained over an eighteen year period, and in 1949 it was higher than it was in 1925. It may be suggested that if this annual take had not been maintained, the timber wolf population would be higher than it is now. Such a view seems doubtful in the light of population studies that have been conducted in the United States. Errington (1936) suggests that the take-off of animals which are surplus to the breeding stock has little effect on the over-all population.

The number of bounty claims submitted with respect to brush wolves annually in the period 1925–49 is also shown in Table 2. The most striking feature is the disproportionate upswing in the take during the period 1925–30. It is in such an instance as this, if anywhere, that bounty claim statistics may be taken as a very broad index of predator population. Cross (1937b) states that brush wolves suffer violent periodic fluctuations in numbers resembling the rise and fall in numbers that occurs among hares. He adds that this is not limited to Ontario, but may be traced in Canadian fur records for a hundred years.

As has been stated above, the bounty on brush wolves was raised from $10.00 to $15.00 in 1926. This apparently had little effect in keeping down the population, which must have increased enormously to allow the take-offs in-

dicated. On the same basis, it is not practical to assume that the bounty was responsible to any great extent for the very sharp decline which must have occurred in the period 1928–30. The relative constancy of the take over the period 1930–33 will be noted, and 1925–30, and there is little reason to assume that it would suddenly become effective in 1936.

The number of pup pelts submitted for bounty payment over the period 1925–40 also shows marked variations. There is a pronounced peak in 1926,

TABLE 2. SHOWING NUMBER OF BOUNTIES PAID ON EACH SPECIES OF WOLF ANNUALLY IN ONTARIO IN THE PERIOD 1925–1942

Fiscal Year Ending Oct. 31	Timber	Brush	Pup	Total	Bounties and Expenses
1925	831	1,066	21	1,918	$25,465.62
1926	1,022	2,690	107	3,819	51,994.42
1927	1,041	4,414	59	5,514	82,970.07
1928	1,231	4,878	64	6,173	91,297.27
1929	1,165	2,389	34	3,588	53,495.13
1930	1,070	1,458	23	2,551	38,074.77
1931	1,376	1,336	39	2,751	55,873.80
1932	1,413	1,413	46	2,872	68,481.35
1933	1,112	1,229	43	2,384	53,433.88
1934	990	812	57	1,859	27,080.65
Period ending March 31					
1936	1,159	1,713	33	2,905	42,399.89
1937	1,090	1,197	31	2,318	33,360.63
1938	1,022	837	30	1,889	27,474.24
1939	1,031	723	41	1,795	25,357.00
1940	1,107	614	22	1,743	25,058.12
1941	738	400	8	1,146	16,477.43
1942	1,199	577	37	1,813	40,593.77
1943	935	497	32	1,464	30,606.62
1944	1,302	731	32	2,065	46,545.75
1945	1,321	665	12	1,998	45,993.58
1946	1,266	777	30	2,073	44,999.87
1947	1,440	1,182	42	2,664	59,275.18
1948	1,515	961	74	2,540	54,923.38

The above figures are taken from the Annual Reports of the Ontario Department of Game and Fisheries and Lands and Forests.

the drop in 1934. This drop may be artificial in some degree, caused by the falling bounty. Another increase is noted in 1936, and then a steady falling off to an extremely low figure in 1941. This low in 1941 is probably artificial, caused by economic conditions, but a drop in wolf population over the period 1936–40 may be indicated by the figures. Whether this drop is due to the bounty, however, is doubtful. We have seen that the bounty was not effective in halting the rise of population in which is two years prior to the peak of the brush wolf population. There is also a peak in 1934, again two years prior to a lesser peak in the population of brush wolves in 1936. There may be a relationship here, as an increase in adults would be preceded by an increase in pups, which might result in more pups becoming available to the trapper or farmer. If this is true, such a disproportionate increase in claims in respect to pups as is seen in 1926 might be useful in predicting another

upswing in adult population. Also this curve may give an indication of which fluctuations in the curve for adult take are due to economic considerations, and which are due to natural considerations. Thus, the dip in pup take in 1941 coincides with a similar dip in adult take of both species in that year, and is probably artificial in all cases. This is borne out by the recovery in 1942, possibly under the stimulus of an increased bounty.

TABLE 3. SHOWING THE NUMBERS OF CLAIMS ORIGINATING IN THE DISTRICTS OF KENORA, THUNDER BAY AND RAINY RIVER AND THOSE ORIGINATING IN THE REMAINDER OF THE PROVINCE

Fiscal Year Ending Oct. 31	Originating in Thunder Bay, Kenora and River	Originating in Remainder of Province	Total
1925	1,295	627	1,922
1926	2,960	857	3,817
1927	4,386	928	3,514
1928	4,862	1,126	5,988
1929	2,429	1,159	3,588
1930	1,412	1,139	2,551
1931	1,354	1,397	2,751

The totals paid out in claims over the period 1925–49 are of little interest from a biological stand-point. However, compared with the number of claims submitted annually over this period, it shows that the cost of the bounty system is not always commensurate with the number of pelts taken. It will be noticed that when the take became low in 1930, the bounty was increased. This occurred again in 1941.

As has been stated above, one of the main purposes of this bounty system in Ontario is the protection of game for hunting. Its effectiveness in this regard is difficult to estimate since the only criteria available in this respect until very recently were the annual reports of the Department of Game and Fisheries which give qualitative information only. The report for 1929 states "According to reports received from district superintendents, it appears that deer and moose are more than holding their own in the northern and north-western sections of the Province." A consideration, of Table 3, which shows the number of claims per annum originating in the Kenora, Thunder Bay, Rainy River districts, in comparison with the number of claims originating from the rest of the Province, through the period 1925–31, shows that the increase in claims for the Province over this period had its origin entirely in the north-western portion of the Province, at a time when deer and moose were "more than holding their own" in this area. Again in 1930 the north-western portions of the Province are mentioned as those in which big game conditions are improving, and again the majority of applications come from this area.

The situation is evident in every annual report of the Department from 1929 to 1937. The areas specifically mentioned as those most favourable for big game in the reports of the resident game wardens and district superintendents, are those in which over 50% of the bounty applications for the whole Province originate. It would certainly appear, on the basis of these reports, that in this area anyway, a substantial wolf population is living with a prey population, apparently with no detriment to the prey population. Such a situation is, of course, to be expected. The predator population will be found where there is food available, but the point is that in spite of this, the prey population continues to thrive.

However, the areas mentioned above

are those in which hunting pressure upon the deer is relatively light, owing to their distance from large centres of population. The areas in which hunting pressure is greatest will now be considered. The northern counties and districts of southern Ontario, i.e., Haliburton, Renfrew, Muskoka and Parry Sound, are specified in the reports of the Department for 1936–37–38 as those in which the greatest concentration of hunters occurred during the open season. The report for 1936–37 states of these areas, "conditions are reported to be satisfactory and as yet good hunting is available there." That for 1937–38 says, "in some sections of these areas, these animals are still sufficiently plentiful and showing some increase in numbers." In 1938–39, "they are more than holding their own" in these areas and in 1939–40 they are stated to be "plentiful and increasing." In each year from 1936 to 1940 over 20,000 deer licences were taken out by hunters, the majority of whom hunted in the areas described above.

Examination of Table 4 will show that the annual take of wolves in this area during the period 1936–42 has flucutated between 100 and 175. The vast majority of these claims have been for timber wolf pelts. Timber wolves are much more destructive to deer than are brush wolves.

Thus we have a situation in which the deer population appears to be sustaining itself effectively, and even increasing, in the face of heavy hunting pressure, combined with the predation factor of a wolf population which can withstand an annual take-off of 100 to 170 of the species which is most important in deer predation. The very fact that these two populations can sustain the depletions indicated above is evidence that they are both well established in this area, and it appears the depletions affect only the annual surplus, leaving the breeding stock untouched in both cases. Gabrielson(1941) says that reduction of a predator species may sometimes be desirable if the prey species is subjected to a very heavy hunting pressure. However, here we have the two populations living side by side, the deer withstanding both predation and hunting pressure, and the wolf sustaining hunting pressure only. Here, as in the rest of the Province, the fact that the wolf take is maintained at a fairly constant level annually indicates that the local nucleus of breeding stock is not being affected by the annual destruction, but only the surplus. It is a well-known ecological principle that, of all the offspring produced by a pair of parent animals, only two must survive to reach maturity and breed if the population is to remain constant. The bounty statistics for timber wolves indicate that this population has remained constant. The surplus is killed off by disease, natural enemies, food shortage, and, to some extent in this

TABLE 4. SHOWING NUMBER OF CLAIMS FOR EACH SPECIES AND PUPS ORIGINATING IN THE HALIBURTON, MUSKOKA, PARRY SOUND, RENFREW AREA PER ANNUM FROM 1936 TO 1942.

Period ending Mar. 31	Claims for Timber Wolves	Claims for Brush Wolves	Claims for Pups	Total
1936	143	22	1	166
1937	136	11	1	168
1938	90	10	0	100
1939	116	20	0	136
1940	154	7	0	161
1941	96	7	0	103
1942	148	25	0	173

case, by bounty claimants. The natural balance is difficult to upset over a large area. Cross (1937b) likens the attempt to reduce the Ontario wolf population by bounties to dipping a pail of water from a flowing stream, and suggests that killing off some of the surplus in this way makes it easier for those that remain.

TABLE 5. DEER LICENSES SOLD IN ONTARIO, 1936–1949

Year	Resident	Non-Resident	Total
1936	21,042	848	21,890
1937	25,458	1,036	26,494
1938	29,788	1,329	31,117
1939	29,461	1,492	30,953
1940	27,015	1,291	28,306
1941	32,891	2,028	34,919
1942	38,191	1,518	39,709
1943	38,296	1,782	40,078
1944	38,654	2,385	41,039
1945	53,930	4,430	58,360
1946	62,913	7,877	70,790
1947	67,299	11,193	78,412
1948	73,700	11,300	85,000
1949	83,000*	12,000*	95,000*

* Estimated figure.

Within the last few years an attempt has been made to gather some basic information on the white-tailed deer in Ontario. Although no general picture can be formed as yet, certain points emerge which are worthy of note.

Table 5 shows the number of resident and non-resident deer licences sold in Ontario annually since 1934. The most notable feature of these figures is the tremendous increase in hunters in the last fifteen years. There is no doubt that hunting success has declined appreciably since the war, but in view of the five fold increase in hunting pressure, this can scarcely be attributed entirely to predation. Some evidence indicates that the annual deer kill is relatively constant, but is spread out over a greater number of hunters.

The department of Lands and Forests operates a checking point in southern Ontario each deer season. This is located on the principal North–South highway of the Province, near Gravenhurst and information is received from hunters who have covered a wide area north and east of Lake Huron.

Table 6 shows the results of this check in three years. These figures are of comparative value only, since no estimate of hunting effort or area covered is available, but it is noteworthy that while the number of hunters checked has more than doubled, the kill shows only a slight increase. The impression conveyed to the individual hunter is, of course, one of a steadily declining game population, and the wolf is a convenient scapegoat. The solution to the problem is deeper than the killing of superficial elements of the wolf populations.

Statistics indicate that the bounty does offer a definite stimulus to wolf destruction in Ontario. The opinion is expressed by Seagears (1944) and by Gerstell, (1937), that a large amount of the money paid out in bounties goes to claimants who would have killed the animal presented for sport, protection of property, etc., without the additional inducement of the bounty. However, the statistics for Ontario, where available, reveal that between 45 and 50 per cent of the wolves killed annually

TABLE 6. INFORMATION TAKEN AT HIGHWAY CHECK POINT, GRAVENHURST, ONTARIO

Year	Number of Days Check Carried on	Number of Hunters Checked	Number of Deer Taken
1941	15	4,264	3,001
1946	14	7,389	3,280
1948	13	9,570	3,277

are taken in snares set specifically for wolves, and about 25 to 30 per cent are trapped, the remainder being shot, poisoned, etc. The Game and Fish Commission for 1911 reports that the most usual and effective method for the destruction of wolves apparently was poisoning, but owing to the fact that many objections had been raised against its use, it was declared illegal to place poison where other game was liable to find it. However, it was plainly impossible to place poison for wolves where other game would not find it, and the report of the Commission states that the illegality of placing poison at that time was "more or less winked at." The Commission recommended that poisoning be made legal, within bounds, but, in spite of the recommendations of this Commission, poisoning seems to be unpopular, and only 2 or 3% of the annual take is attributed to this method. The snare now seems to be the most popular method.

There is one respect in which the bounty is desirable. It undoubtedly supplies a welcome supplement to the none too ample income of the northern farmer and trapper. Generally, over 80% of the pelts submitted for bounty come from farmers, trappers and Indians, and the annual reports of the Department for 1931 and 1932 state that wolf trapping was the most remunerative branch of the trappers' trade at that time. In 1928 wolf fur was in great demand for trimming, and the price of the pelt, added to the bounty, brought the trapper $30.00 to $40.00. Also, the fact that the bounty monies disbursed in Ontario are well distributed is evidenced by the figures quoted in the report for 1937–38, which states that for the 1,889 pelts presented, bounty was paid to 1,109 persons, 735 claiming for one skin each, 179 for two skins each and the remainder for varying numbers. The largest amount paid to any one person was $210.00.

There is little evidence in Ontario of the fraud which has characterized much of the dealing in bounties in the United States (Jacobsen, 1945). Before 1911 in Ontario, it was necessary to present only the ears of the animal in claiming for bounty and there is evidence of fraudulent practice before this time. But since then, there have been few cases of prosecutions in this matter. In 1936 a claim was submitted on five coyote pups which were proved to have been imported from the western Provinces and the claimant in this case was prosecuted. Every year between ten and twenty claims are disallowed because the skins presented are found to be dog skins, fox skins, etc., and occasionally skins of unborn pups taken from the carcass of the mother are presented, but no prosecution is instituted in these cases.

SUMMARY AND CONCLUSIONS

Biologists and conservationists look upon the bounty system as a method of control of predators with less favour than formerly, because indications are that predation is not as important in determining animal populations as was formerly believed.

There is evidence for the belief that bounties usually result in the killing off of only the surplus predator population, leaving the nucleus of breeding stock untouched.

With particular reference to Ontario, it is the bounty on wolves which must be studied and a brief history of this is given. A great deal of money has been

spent on bounties in the Province since 1905, but it is impossible to evaluate the results of this expenditure, either in a reduction of predators, or an increase of game species, owing to the scarcity of factual data on the wildlife resources of the Province. The evidence available indicates that this expenditure has had practically no effect on either the timber wolf or the brush wolf population of the Province.

As a method of protecting game, it appears again that the bounty on wolves has had little effect. It is found that the greatest number of bounty claims originate in those areas in Ontario where the deer are thriving, according to available reports. This applies especially in those more inaccessible areas where hunting pressure on the deer is light. But the figures for wolf take even in the most heavily hunted area of the Province, i.e., the northern portions of southern Ontario, indicate that there is a substantial wolf population living beside the deer population, and the latter continues to thrive in the face of both the hunter and the wolf.

The bounty is undoubtedly a stimulus to wolf destruction because the majority of claims presented are for animals taken in snares or traps set specifically for wolves.

As a supplement to the income of the northern farmer or trapper, the bounty is no doubt desirable. For several years, wolf trapping was the most remunerative branch of the trappers' trade.

There is little evidence of fraudulent practice in bounty dealings in Ontario. Although a few claims are disallowed every year, generally because the skins of dogs or foxes are presented, actual prosecutions are few and far between.

The effect upon the wolf population of the present bounty system is dubious in the light of available data. The constancy of the annual kill of timber wolves indicates that this species is not being seriously depleted, and the take of brush wolves seems to follow fluctuations which are little influenced by the annual kill. The bounty system is undoubtedly a stimulus to wolf destruction in Ontario as indicated above, but more information will be necessary before it is possible to assess such control as has been effected in terms of big game production.

REFERENCES

ANONYMOUS. 1911. Report of the Ontario Game & Fisheries Commission 1909–1911. 215–217.

———. 1933. Report of the Special Committee on the Game Situation 1931–1933. Ontario Sessional Paper #32.

CROSS, E. C. 1937a. Wolf! Wolf! Rod and Gun in Canada, January 1937.

———. 1937b. The White-tailed Deer in Ontario. Rod and Gun in Canada, Feb. 1937.

ERRINGTON, P. L. 1936. What is the meaning of predation. Smiths. Report **1936**: 243–252.

GABRIELSON, I. N. 1941. Wild life conservation. Macmillan.

GERSTELL, R. 1937. The Pennsylvania bounty system. Game Research Bull. #1. Pa. Game Commission 1937.

HENDERSON, J. and E. L. CRAIG. 1932. Economic Mammalogy. Thomas.

JACOBSEN, W. C. 1945. The bounty system of predator control. Calif. Fish and Game, **31**: 53–63.

SEAGEARS, C. B. 1944. The fox in New York. Educational Bull. New York Conservation Dept. Oct. 1944, 45–48.

STEBLER, A. M. 1944. The status of the wolf in Michigan. Jour. Mamm., **25**: 37–43.

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FISH MORTALITY CAUSED BY A SERIES OF HEAVY EXPLOSIONS IN CHESAPEAKE BAY[1]

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During the late spring and summer of 1948, the Bureau of Ships, Department of the Navy, conducted a series of underwater explosive tests off Barren Island in Chesapeake Bay. Because of previous fish mortalities in the Bay caused by numerous military operations over the past decade, considerable public resentment over the proposed tests was expressed in the press and among commercial fishermen and sportsmen groups. As a result of these protests, both the Maryland Department of Research and Education and the U. S. Fish and Wildlife Service were requested by the Navy to send observers.

In all, 26 charges of HBX[2] were exploded, ranging from 250 to 1,200 pounds. They were detonated at depths ranging from 17 to 134 feet. We observed 21 of these tests.

Security regulations prohibited the observers from having any advanced information on the size of the charge or the nature of the test. It was not possible, under the conditions of the tests, to plan for any experimental observations. Our efforts were, therefore, limited to estimating the numbers and weights of each species of fish killed or injured. We were most interested in those fish of commercial importance.

[1] Joint contribution from the Chespeake Biological Laboratory and the U. S. Fish and Wildlife Service.

[2] A high explosive, more powerful than TNT. Exact specifications are restricted by the military.

Test Area and Procedure

The test site (Figs. 1 and 2) is a very interesting one biologically. Cowles (1930) lists nine deep holes within the Bay which are connected by waters deeper than average depths. Depths for these holes range from 114 feet to 156 feet, whereas depths of 30 to 40 feet are about average for deep water in Chesapeake Bay. The test site is located over the deepest of these holes. This hole lies on the eastern side of the Bay about 2½ miles from Barren Island and just opposite the mouth of the Patuxent River. The bottom was sampled with a Petersen dredge. It proved to be thick, sticky, black mud, when wet. Freshly collected samples smelled strongly of hydrogen sulfide. No macro-organisms could be found in this mud despite a diligent search for them.

During the tests, several ships and barges were anchored in fixed positions (Plate 12). Two of these were the targets being studied. These were anchored in water 134 feet deep. One target measured approximately 420 feet in length, the other about 660 feet. Although both vessels were relatively clean, some growth, including barnacles, had accumulated on their hulls. It is possible that this growth attracted fish.

The schedule for firing varied, but an attempt was made to fire as close to slack water as working conditions permitted. Only one shot was fired in any one day. No firing was done at night.

Two small fast boats were placed at our disposal by the Navy for recovering dead fish on most tests and from 2 to 4 men dipped fish with hand nets from the water.[3] About ten minutes before firing time, recovery boats took positions just outside the buoy line marking the danger zone, one on each side of the target ship. As soon as the charge was fired, they speeded to the target area. By actual timing on several tests, boats reached the up-welling water in less than two minutes. Fish found at the

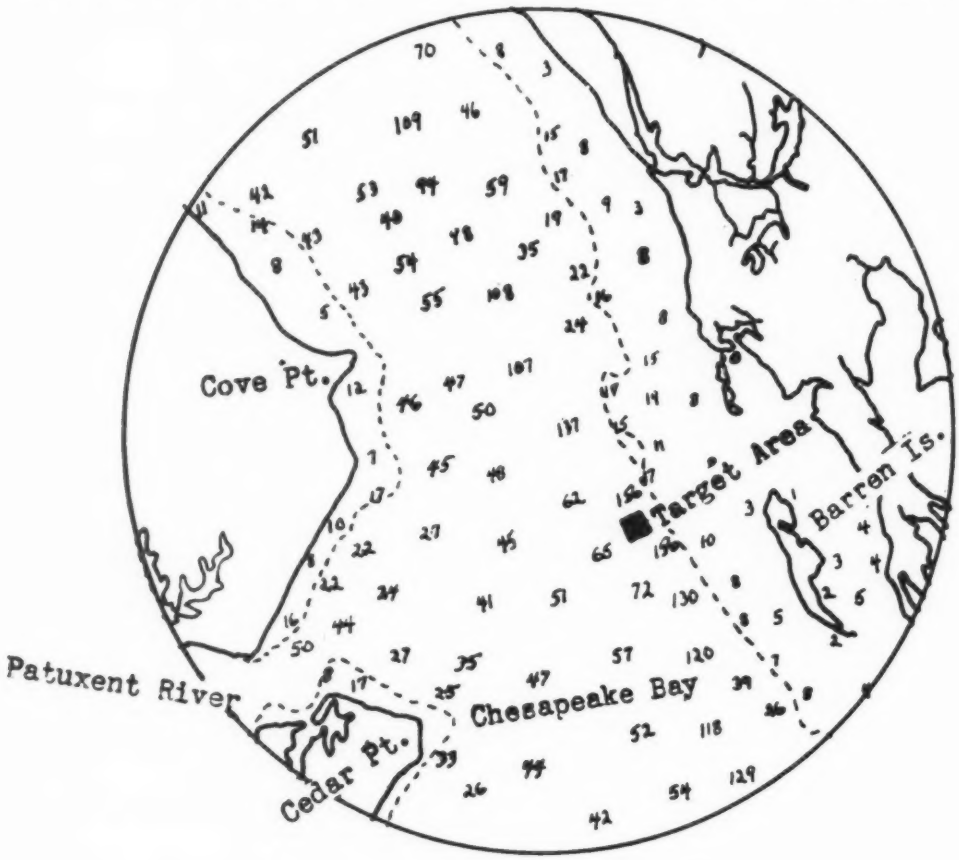

FIG. 1.—Depths, in feet, at the explosion site.

[3] In addition to the authors, the following people assisted from time to time in fish recovery: Thomas S. DeLong, Harold J. Elser, George Gray, Harry A. Hensel, Jr., Thomas C. Hopkins, Jr., George F. Kelly, Galen H. Maxfield, Harvey Mister, Walter A. Sheppe, Fred W. Sieling, Philip B. Whitford. Their help is greatly appreciated.

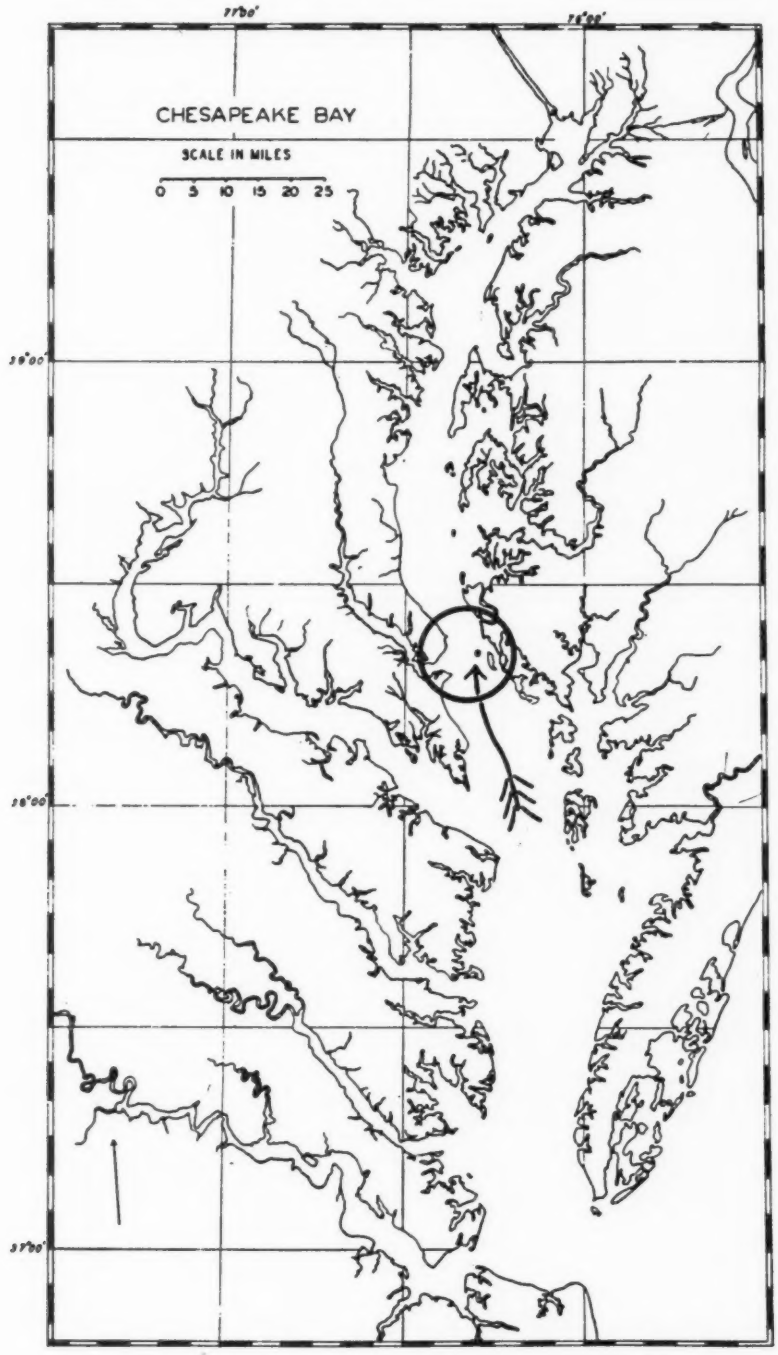

FIG. 2.—General location of the explosion site.

TABLE 1.—RESULTS OF TWENTY-ONE EXPLOSIONS OFF BARREN ISLAND, MARYLAND

Date	Weather	Water Cond.	Size of Charge (lbs.)	Depth of Charge (ft.)	Menhaden		Croaker		Trout		Rock		Miscellaneous		Total	
					Number	Wt.	Number	Wt.	Number	Wt.	Number	Wt.	Number	Wt.	Number	Wt.
5- 6-48	Warm, sunny	Choppy	640	68	1,876	856	32	56	36	20	52	296	84[a]	18	2,080	1,246
5-21-48	Bright	[1]	250	70	8,000	5,496	—	—	—	—	—	—	35[b]	10	8,035	5,506
5-27-48	Cloudy, warm	[1]	600	70	1,000	800	—	—	—	—	4	85	1[c]	—	1,005	885
6- 1-48	Partly cloudy, Mod. N. wind	Very rough	1,200	70	No kill, gulls present, not diving											
6-11-48		[1]	600	70	292	128	72	68	34	14	—	—	88[d]	6	486	216
6-15-48	Clear, sunny	Calm	640	68	448	376	292	408	40	26	8	128	48[e]	44	836	982
6-18-48		Choppy	1,200	70	1,420	503	—	—	12	4	2	19	4[f]	1	1,438	527
6-23-48	Sunny, hazy, lt. NE breeze	Smooth	600	70	6,000	4,870	16	40	6	7	—	—	6[g]	5	6,028	4,922
6-25-48	Hot, humid, misty	Smooth, sm. waves	600	17	253	201	—	—	—	—	—	—	1[h]	—	254	201
7- 2-48	Warm, lt. breeze	Sl. choppy	600	17	208	91	—	—	—	—	—	—	—	—	208	91
7 -8-48	Clear, sunny, lt. breeze	[1]	1,200	70	325	143	—	—	6	5	—	—	—	—	331	148
7-12-48	Warm, sunny, mod. south wind	Very rough	1,200	70	2,900	1,300	22	42	96	89	—	—	267[i]	17	3,285	1,448
7-15-48	Overcast, warm, lt. south wind	Choppy	450	68	604	242	1	2	1	1	—	—	—	—	606	245
7-20-48	Hot, lt. breeze	[1]	640	70	1,288	343	—	—	1	1	—	—	1[j]	—	1,290	344
7-27-48	Warm, sunny, interm. showers	Mod. waves	1,200	70	260	64	—	—	32	22	—	—	—	—	292	86
7-29-48	Warm	Average	1,200	70	4,000	1,132	—	—	4	3	—	—	—	—	4,004	1,135
7-30-48	Sunny, warm	Average	250	53	1,667	408	—	—	2	1	—	—	—	—	1,669	409
8- 3-48	Sunny, warm, later stormy	Calm to rough	1,200	110	240	160	—	—	21	14	—	—	1[k]	—	262	174
8- 9-48	———	[1]	250	134	156	62	—	—	100	60	—	—	92[l]	8	348	130
8-10-48	———	Smooth	250	119	27	12	—	—	33	23	—	—	20[m]	2	80	37
8-11-48	Overcast. mod. SW wind	Rough and choppy	250	65	70	39	18	23	33	28	—	—	—	—	121	90
	Totals		15,020		31,034	17,226	453	639	457	318	66	528	648	111	32,658	18,822

Weights, here given in pounds, were determined by weighing individual fish or by weighing the entire recovered sample of each species and using the average weight to estimate the total poundage of that species for that test. Weights of samples aggregating less than one pound were not used. In a few instances, lengths or weights, when only one was measured, were estimated from previous observations.

[1] Condition not noted at time of recovery.

[a] Alewife 60, fry 24. [b] Sand perch 34, fry 1. [c] Alewife 1. [d] Alewife 66, hickory shad 14, shad 4, sand perch 2, silver hake 2. [e] Shad 36, hickory shad 4, alewife 4, silver hake 4. [f] Hickory shad 2, alewife 1, sand perch 1. [g] Shad 2, silver hake 2, silverside 2. [h] Silver hake 1. [i] Spot 247, sand perch 16, shad 2, alewife 2 [j] Shad 1. [k] Halfbeak 1. [l] Spot 60, harvestfish 32. [m] Spot 14, silverside 3, harvest fish 1, gizzard shad 1, sand perch 1.

surface were bailed into the boat to be measured, weighed and counted later. Each boat patrolled its side of the target until most of the fish were recovered. When complete recovery was impractical, an estimate of the total number of fish remaining in the water was made by counting the fish in a sector, and estimating by inspection the number of such sectors in the area where fish were floating, allowance being made for unequal species dispersion. In most of these tests, at least two hours were spent in recovery. On only one date, August 3, was less than one hour spent.

OBSERVATIONS

The details on the numbers and weights of fish recovered during these tests are given in Table 1. In the 21 explosions which were observed, at least 32,658 fish were killed or injured. The fish weighed 18,822 pounds. By far, more menhaden were killed than any other species. This species has little direct commercial value in Maryland waters. When used, it is worth about one cent a pound as crab bait. Of the other fish killed, only croakers, rock, and trout were in quantities in excess of 100 pounds. Less than 1,600 pounds were marketable food fish and no large quantities of immature food fish were encountered.

It appeared that ordinarily fish were damaged only within a radius of 100 to 200 yards from the detonation point, but on a few tests fish surfaced shortly after the explosion a considerably greater distance away from the target area. On one test, July 12, spot appeared at the surface a few minutes after the explosion at least 500 yards from shot point. Coker, Elser and Maxfield observed some of these tests and had also observed tests in another area in which conditions were very similar except for the presence of vessels. The species composition was the same. In the earlier tests, they seldom observed fish more than 100 yards from shot point immediately after an explosion. The principal observed difference in the two series of tests is that in the present series several large steel hulled vessels were anchored close by the explosions. The Chesapeake Biological Laboratory report (1948), p. 14, points out: "In general, the pattern of waves produced by underwater explosions is quite complicated because of the geometry of the system, wave velocities, and elastic properties of the bottom." This suggests that the large vessel hulls, in the immediate proximity of the explosions, probably played an important role in the geometry of these explosive tests and may have extended the range of lethal action.

The position in which the fish floated at the surface was characteristic of the species and made it possible to identify most species at some distance. Menhaden floated nearly flat on their sides, their bellies only slightly distended. The croakers and trout, whether dead or injured, floated belly upward; their bellies were always distended. The large rock floated head upward, their bodies hanging down almost perpendicular to the surface of the water. Small rock tended to float belly upward in much the same position as the trout and croakers, though somewhat lower in the water. The shad and alewives floated somewhat like the menhaden, though usually their bodies were unilaterally contracted.

UNKNOWN KILL

Fish found floating on the surface following an explosion do not constitute all of the fish affected. Certainly some fish fail to surface—those without swim bladders and probably some badly damaged ones temporarily capable of locomotion. Chesapeake Biological Laboratory (1948) observations in a nearby area reported (pp. 19–20) "Accumulations of dead menhaden on the bottom frequently made sampling by oyster dredge difficult and indicated that this species of fish may be killed in larger numbers than would be estimated from the dead fish which float to the surface." The work of Fitch and Young (1948) suggests that from ½ to 1/12 of the fish mortality may not be visible from surface collections. We had no opportunity to determine what percentage of the fish killed in these tests failed to surface. On one of the days when there was a large kill of menhaden attempts were made to drag an oyster dredge ("hand scrape") to pick up dead fish that might have sunk to the bottom. No fish were brought up in the dredge; however, there is some doubt that the dredge operated properly at the comparatively great depth and on such a soft bottom. We do know that some of the smaller menhaden, up to about 20 cm., would surface and then sink, often before we could recover them. Some of the larger rock, obviously injured, disappeared if our first attempts to net them were unsuccessful. Croakers and trout apparently continued floating for as long as two hours.

No sustained special effort was made during this series of explosions to recover very tiny fry and larvae; they are practically invisible under the conditions due to their small size and transparency. Since some were recovered with a fine-mesh dipnet, it is very likely that they were present in much greater quantity than is indicated by the figures in Table 1 under the heading "Miscellaneous" (footnotes a and b). Worth noting, however, is that the larvae of shad, alewives and rock would not be expected to be in the area, for they spawn in early spring well upstream in the tributary rivers and the young remain in river waters until later in the summer, by which time they have attained a length of several inches. Best information available on croakers (Wallace, 1940) is that they spawn off-shore at the mouth of the Bay in the fall and early winter and the larvae, in turn, are swept into and up the Bay by a deep subsurface counter movement of water. Wallace found free-swimming postlarval croakers at depths of 24 meters and deeper at this level in the Bay during winter and early spring. Whether the young croakers would still be present during later spring and throughout the summer in this deep water is not yet known, but in any event by that time they should have attained appreciable size. According to Hildebrand and Schroeder (1928) sand perch spawn in the Bay in late spring and early summer; hence it is possible that sand perch larvae were present. Little is known about the situation in regard to trout and spot.

Reports were heard on one occasion that while the tests were in progress, large numbers of dead rock appeared on the shore near Rock Hall, a distance of more than 45 miles from the test area. Mortalities of fish have been reported periodically in Chesapeake Bay,

but it is usually very difficult to trace their cause. It would be presumptuous to ascribe the loss of these fish to these tests in view of the distance involved and especially since similar drifts of dead fish have been reported, both before and after the tests were conducted.

NATURE OF INJURY

Different categories of injuries were noted in the fish recovered following these explosions. The fish seldom showed gross external injuries. On one test only, a few menhaden were blown to shreds and on another test one menhaden was observed to have had its mouthparts dislocated and its sides lacerated. Occasional specimens of the dominant species were seen with eyes protruding from their sockets. The damage inflicted in most instances was internal. Croakers were sometimes observed with the gut protruding from mouth and anus. A few trout were seen with the gut protruding posteriorly. All specimens of croakers, trout and hake had distended abdomens. This distention of the abdomen was not apparent in the large rock, but was noticeable in the smaller sizes of rock. The internal injuries for all fish examined, invariably showed a ruptured air-bladder and some degree of hemorrhage of its vascular system. There was frequent evidence of ruptured blood vessels in liver and spleen.

DISCUSSION OF RESULTS

It is clear (Table 1) that neither the number nor weight of fish killed is in proportion to the size of the charge. In the 250 pound charges, kills ranged from .15 to 22.02 pounds of fish per pound of explosive, while for the 1,200 pound charges, the kills were actually less per pound of explosive, the values ranging from 0 to 1.21 pounds. The heaviest kill, both in numbers of fish and numbers of pounds, was the result of a 250 pound charge detonated at mid-water depth on May 21. This charge killed 32.14 fish per pound of explosive, or 22.02 pounds of fish per pound of explosive.

Two of the lightest kills resulted from 600 pound charges detonated at 17 feet on June 25 and July 2. With the exception of a single hake, only menhaden were killed. Menhaden frequently may be seen to swim near the surface, whereas croakers and trout probably frequent mid or lower depths of water most of the time. Hand-line fishing for the latter species bears this out. Eklund (1946) reported a negative kill as the result of twenty-two 500 pound high explosive bombs on the ice-covered Wapawekka Lake, and he attributed this to the possible seasonal migration of the white fish, which is the dominant commercial fish there, to deeper waters than those of the target area. However, since trout were present in our test site both before and after these shallow shots, it would appear that there may have been a kill here only in the upper strata of water.

Aplin (1947, p. 23) suggested that "... there was some indication that few fish were killed during rough weather." Our observations both support and contradict this view. In this series of tests, there were two days on which the water was extremely rough. On both days, shots of 1,200 pounds at 70 feet were used. On June 1, there was not a trace of fish following detonation,

although a diligent search was made covering a wider area than usual. But on July 12, the kill was the seventh largest in pounds of fish, and sixth in numbers of fish killed per pound of explosive. A lighter charge on August 11, when the water was moderately rough, produced a fairly light kill.

as is known, the test site does not have a permanent resident fish population.

The fact that rock were observed in four of the first seven tests but not later than the test of June 18, is interesting and might indicate that these were killed off or driven away. However, it is more likely that they moved because

TABLE 2.—SPECIES AND SIZE RANGES RECOVERED AFTER EXPLOSIONS

Species	Lengths[1]	
	Minimum (cm.)	Maximum (cm.)
Menhaden—*Brevoortia tyrannus*	4.5	34.5
Croaker—*Micropogon undulatus*	24.5	47.5
Trout, gray & spotted—*Cynoscion regalis* and *C. nebulosus*	19.0	43.5
Rock, Striped Bass—*Roccus saxatilis*	33.5	106.0
Alewife, Branch herring—*Pomolobus pseudoharengus*	7.5	12.0
Alewife, Glut herring—*Pomolobus aestivalis*	9.5	22.5
Hickory shad, Hickory Jack—*Pomolobus mediocris*	7.5	10.0
Shad—*Alosa sapidissima*	17.0	48.0
White Perch, Sand Perch—*Bairdiella chrysura*	16.5	22.5
Spot—*Leiostomus xanthurus*	9.0	16.5
Silver hake—*Merluccius bilinearis*	17.5	20.5
Silverside—*Menidia menidia*	6.0	10.5
Half beak—*Hyporhamphus unifasciatus*		
Harvestfish—*Peprilus alepidotus*	4.5	6.5
Gizzard shad—*Dorosoma cepedianum*	20.0	20.0

[1] Fish lengths throughout this account were measured to the nearest half-centimeter. The length from the snout to the fork of the tail was used with fish having a forked tail; total length from the snout to the end of the caudal fin was used for fish having rounded tails.

There did not appear to have been any selective mortality for size of fish. The size range included fish from 3 to 106 cm. The range of sizes represented in our recovery seemed typical of the sizes present in the Bay at that time. (Table 2).

There is no reason to believe that fish were frightened from this area as the result of these explosions. Mortality in both numbers of fish and pounds of fish varied widely throughout the series of tests, and the species composition for the bulk of the fish remained fairly constant. Nearly all of the fish listed are more or less migratory and as far

of other conditions. Usually during summer months, rock are to be found nearer to shore in water much shallower than at the test site. From the middle of June on toward fall, rock are caught by trolling in shallow areas a few miles away. The test-site has never been a popular fishing ground in summer months. However, it is an important wintering ground for rock and constitutes one of the principal drift gill net fishing grounds from December through March.

It is interesting to compare the averages of fish killed in these tests with tests of other areas even though it is

recognized that in such uncontrolled tests, the kill is governed to a large extent by the quantities of fish present at the test site. Fitch and Young found that their average for open shots, those fired a few feet under the water surface, was 0.47 pound of fish per pound of explosive which was somewhat lower than the value reported by Aplin, who found about 5 pounds of fish per pound of explosive. Our average value was 1.25 pounds of fish per pound of explosive. We found an average of 896 pounds per shot against Aplin's approximate 100 pounds and Fitch and Young's 31.56 pounds. The far heavier charges used in this series of tests may account for our high average. More than likely, however, there were simply more fish present to be killed.

FACTORS INVOLVED

When these tests were first proposed, there was apprehension lest large numbers of commercially valuable fish be killed. That there were not more fish killed is probably due to two factors. The first is the bio-physical factor that the area affected by the explosive force is relatively small. Fitch and Young point out that this force decreases inversely as the cube of the distance. Gowanloch and McDougall (1945) found that croakers were undamaged at distances greater than 200 feet for 800 pound charges of 60 per cent gelatine dynamite. The Chesapeake Biological Laboratory report (1948) of experimental work primarily with 30-pound TNT charges and caged fish states that initial mortality of trout and rock was limited to a radius of 200 feet from the charge. Their experiments were carried out in water about 40 feet deep. The second factor is the possibility that fish in large quantities were not in the area at the time the tests were conducted. It is generally believed that during warm weather most of the fish with which we are concerned feed along the shores and move out into the deeper waters only after the shore waters cool. Although this series of tests was conducted with relatively few fish killed, care must be used in planning such tests to select times when fish are expected to be absent from the test area. In estuarine waters, this may prove complex where many species are involved and the species vary in feeding and spawning migrations.

SUMMARY

Over a four-month period in the late spring and summer of 1948 the Bureau of Ships, Department of the Navy, fired 26 underwater charges of HBX (250 to 1,200 pounds per shot) suspended at various depths in deep water (156′) of Chesapeake Bay at the level of Solomons and Barren Island, Maryland. Observers from the Chesapeake Biological Laboratory of the Maryland Department of Research and Education and from the U. S. Fish and Wildlife Service attended 21 of the explosions and noted the fish that were injured and killed apparent at the surface. Sixteen species were recorded. Totals for the 21 shots included 32,658 fish or 18,822 pounds, with an average of 2.17 fish per pound of explosive or 1.25 pounds of fish per pound of explosive. Menhaden (*Brevoortia tyrannus*) comprised the bulk of the observed kill. This very abundant species has little commercial value in Maryland.

Neither the number nor weight of fish

killed was in proportion to the size of the charge. Normally the radius of area affected did not exceed 200 yards from the explosive charge and generally fell within a range of 100 yards. On one occasion, however, injured spot (*Leiostomus xanthurus*) appeared at the surface at least 500 yards from shot point. Presence of large steel vessel hulls at the site may have influenced the dispersion of the lethal factor by providing reflective surfaces for the shock waves.

Damage inflicted to individual fish was mainly internal, observed primarily as rupture of the swim bladder and of the vascular system of the abdominal cavity and organs. The position in which a fish floated at the surface was characteristic for the species.

It is believed that fish were not driven away from the area as a result of the explosive operations. Some may have been attracted by fouling growth on the target ship hulls. Extent of kill was probably governed by two factors: (1) rapid dissipation of the explosive force with distance away from charge, and (2) presence or absence of fish within the relatively restricted lethal range.

The figures on fish kill presented in this report do not represent the total kill. They are based on collections and estimations of fish appearing at the surface. Some lethally injured fish undoubtedly failed to surface. Fish fry and larvae were also affected in indeterminate number, but it is not likely that larvae of very many commercial species could have been present.

Planning of such operations to select seasons when fish are least concentrated in the area can be a complex problem in an estuarine area such as Chesapeake Bay. The observed kill of valuable commercial varieties in this instance can be considered low, as it totaled less than 1,600 pounds for the entire series.

LITERATURE CITED

APLIN, J. A. 1947. The effect of explosives on marine life. California Fish and Game, **33**(1): 23–30.

CHESAPEAKE BIOLOGICAL LABORATORY. 1948. Effects of underwater explosions on oysters, crabs and fish. Publication No. 70. Chesapeake Biological Laboratory, Solomons Island, Maryland, pp. 1–43.

COWLES, R. P. 1930. A biological study of the offshore waters of Chesapeake Bay. Bulletin of the Bureau of Fisheries, **XLVI**: 277–381.

EKLUND, CARL R. 1946. Effect of high explosive bombing on fish. Jour. Wildl. Mgt., **10**(1): 72.

FITCH, JOHN E. and PARKE H. YOUNG. 1948. Use and effect of explosives in California coastal waters. California Fish and Game, **34**(2): 53–70.

GOWANLOCH, JAMES NELSON and JOHN E. MCDOUGALL. 1945. Effects from the detonation of explosives on certain marine life. Oil. **IV**(12): 13–16.

HILDEBRAND, SAMUEL F. and WILLIAM C. SCHROEDER. 1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fisheries (1927). **XLIII**(1): 1–366.

WALLACE, DAVID H. 1940. Sexual development of the croaker, *Micropogon undulatus*, and distribution of the early stages in Chespeake Bay. Trans. Am. Fish. Soc., **70**: 475–482.

Accepted for publication Feb. 13, 1950.

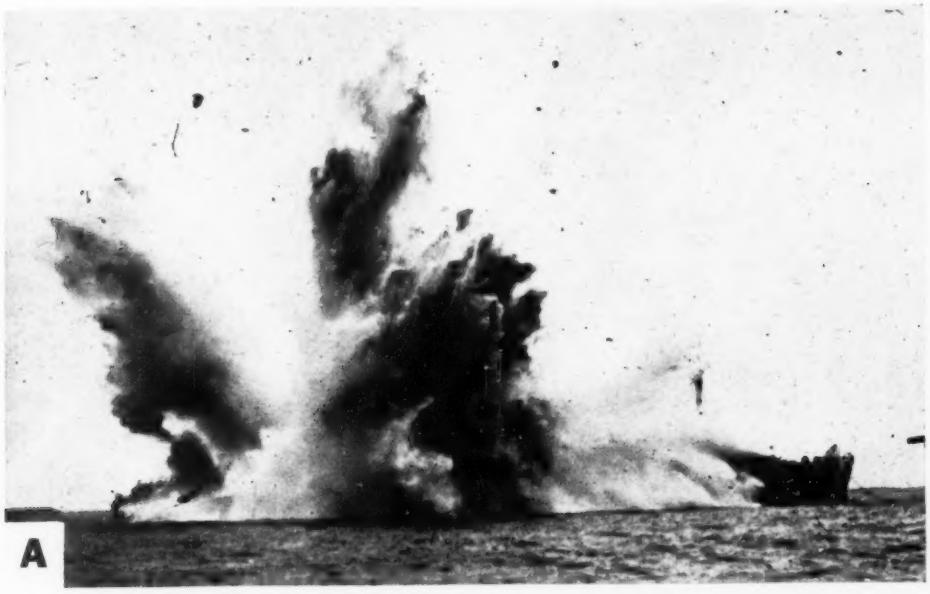

PLATE 12 (A). A 1,200-pound explosion of HBX in Chesapeake Bay.

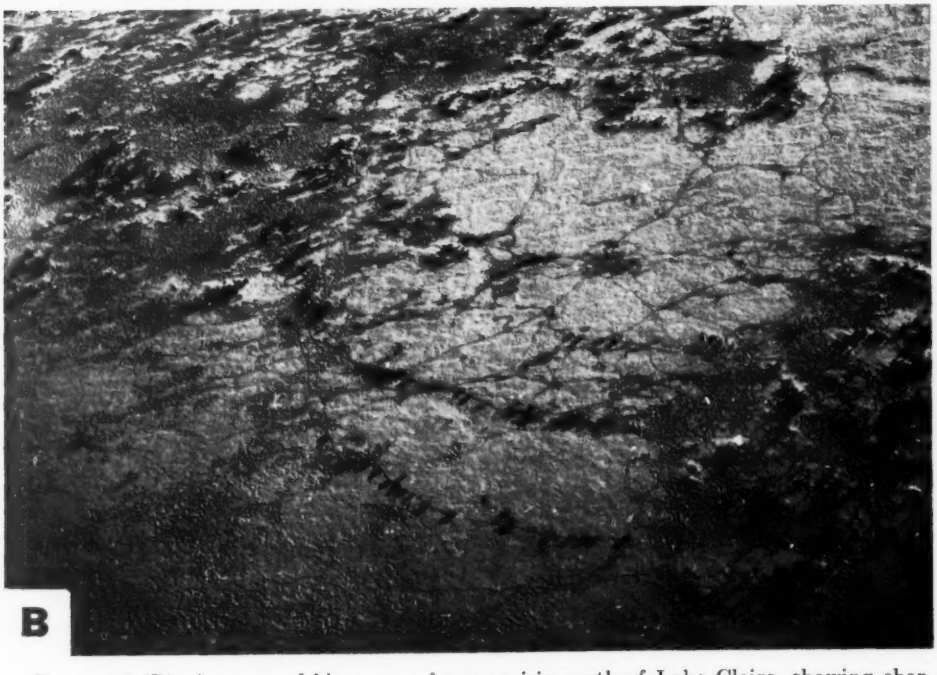

PLATE 12 (B). A group of bison on a large prairie north of Lake Claire, showing characteristic movement in single file. Note also the extensive trampled areas and sparse growth of shrubs. The low angle of the sun is apparent from the length of the shadows cast by the bison.

AERIAL CENSUS OF NORTHERN BISON IN WOOD BUFFALO PARK AND VICINITY[1]

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The largest herd of bison in North America is in Wood Buffalo Park and favorable areas adjacent to it. From time to time attempts have been made to estimate the size of the herd, but there has been little close agreement in either census methods or the resulting estimates. An aerial strip count seemed to offer the best solution to the problems of standardizing technique and making a reliable estimate. The purpose of this paper is to report the results of a strip census carried out from February 4 to February 13, 1949.

Historical Sketch

Full reviews of the early history of the northern bison may be found in Preble (1908) and Soper (1941). The following notes, which deal mainly with previous population estimates, are largely abstracted from these sources.

Originally the wood bison (*Bison bison athabascae*) ranged in considerable numbers over a large area in northern Canada, including that now set aside as Wood Buffalo Park. From about 1850 there was a steady decrease in their numbers until, between 1895 and 1900, it was estimated that only 300 remained. The first protective legislation, making it illegal for anyone to molest the bison, was passed by the Canadian Government in 1893. In 1911 a warden service was established to give more intensive protection. In 1922, when the park was created, it was estimated that there were 1,500 bison in two herds near Fort Smith (Graham, 1923). In 1926 the park boundaries were extended to include a large part of the Peace-Athabaska delta.

During the years 1925–28 plains bison (*Bison bison bison*) were shipped from Wainwright Park to Wood Buffalo Park, and according to the reports of the wardens at this time, readily interbred with the originals. The introduced stock and hybrids rapidly adapted themselves to their new conditions of existence.

J. Dewey Soper was commissioned by the Department of the Interior to make a thorough study of the northern bison and spent two years, from the spring of 1932 to the spring of 1934, on the bison range. His estimate of the population in 1934 was 12,000 animals.

The first attempt at aerial census was made with the co-operation of the Royal Canadian Air Force in 1931. The plan of this survey was to cover the entire winter range and photograph all herds. The attempt was not altogether successful and less than 1,400 animals were photographed. A more recent aerial count was made by the former Superintendent, E. G. Oldham, in 1947 (unpublished report on file at Fort Smith). He adopted the strip

[1] Published by permission of the Department of Resources and Development, Ottawa, Canada.

census method and saw 2,494 bison. On the basis of one-third coverage he estimated 7,482 animals.

EQUIPMENT AND PERSONNEL

For the present census two types of ski-equipped aircraft were used—a De Havilland "Beaver" and a Fairchild "71C." Both machines are capable of cruising at 120 miles per hour and afford excellent opportunities for observation. The "Beaver," being a completely modern machine, equipped with an efficient heater, and especially designed for bush flying, was used for all but two flights. The heater assumes paramount importance when hands must be continually exposed either to make notes or to operate binoculars while the outside temperature is from -10 to $-20°$ F.

Each member of the party was provided with a mounted map on which flight lines were prominently ruled. In addition, the observers carried 6×30 binoculars and notebooks. An Abney level, a K-20 type aerial camera, and a Zeiss plateback camera completed the list of equipment.

The survey party included a pilot, the writer and a second observer. The flight engineer acted as second observer for approximately one-third of the flights, which were all made in the northern section of the park. The Chief Park Warden, I. F. Kirkby, was an observer on the remaining flights, which covered the areas of greatest concentration. It was found that holding accurately to our course required the full attention of the pilot, who was therefore excused from making any observations except to point out herds which were situated directly on the line of flight and which might otherwise have passed unseen beneath the aircraft.

METHODS

The large area of Wood Buffalo Park (17,300 square miles) and the high cost of flying made it desirable to use a sampling method. Parallel lines, running east and west, were flown at intervals of eight miles. Each observer was responsible for a strip one mile wide on his side of the aircraft and the Abney level was used to determine the limits of the strip and to make frequent checks. On all strips every effort was made to maintain a constant altitude of 2,000 feet but minor variations were impossible to avoid since our meteorological and topographical knowledge was limited. From this height, it was calculated that an angle of about 69 degrees from the vertical represented a linear distance of one mile. Since a two-mile strip was surveyed every eight miles, one-quarter coverage was attained.

From previous information it was known that the distribution of the bison was not uniform during the winter. Soper (1941) estimated that 80 per cent of the animals were concentrated on the most favorable winter ranges, which cover an area of only about 1,000 square miles. It was considered that east-west strips at intervals of eight miles would sample the area of concentration adequately and that the intensity of sampling in the areas of greater concentration would be about equal to that in the remainder of the park.

Groups of up to 40 or 50 were usually counted in passing. For larger groups it was necessary to make one or more

circuits and pictures were taken to substantiate the visual count obtained (Figure 1). Observations were recorded directly on the map.

Wherever possible, the number of calves in a group was tallied. No further segregation into age or sex classes was feasible, nor was any attempt made to differentiate between the wood buffalo, the plains race, and hybrids.

A special search was made in one area about 40 miles west of the park boundary, where the reports of local residents led us to believe there was a large herd of bison. Similar reports have reached us from other regions, but it has been impossible to verify them all directly and the estimates of only the most reliable observers have been used in compiling this report.

The total flying time involved, including the special search outside the park, was 29 hours and 40 minutes. Of this, one hour and 50 minutes could be directly charged to administration, which included transportation of personnel and a medical emergency call. The aircraft was chartered at $60.00 per hour, which made the total cost $1,766.00. Approximately 4,500 square miles were brought under direct observation, and an estimated 25 per cent coverage obtained for about 18,000 square miles. The cost was less than ten cents per square mile. There is no basis for comparison with the expense of a ground survey, since such a survey is impracticable in this wilderness area.

CONDITIONS AT TIME OF SURVEY

Physiography of Area. Soper (1939), in describing the physical geography of the park, states that there are four distinct elevations. The Birch Mountains in the southwest, and Caribou Mountains in the west central portion, both erosion plateaus of Cretaceous rock, constitute the highest level. Bison are seldom found on these uplands, although they now range to the base of the eastern slope of the Caribou Mountains.

The second level, a northward extension of the Alberta Plateau, includes most of the park area. It is, in general, a poorly drained region of muskegs, shallow lakes, low rolling sand ridges, and meandering streams. The vegetative cover is typically semi-open stands of aspen (*Populus tremuloides*) and spruce (*Picea glauca*) on the lower lying portions, with pure, park-like stands of jack pine (*Pinus banksiana*) on the sandy ridges. Its eastern margin is a more or less distinct escarpment, best developed in its central portion near the 60th parallel, where it forms cliffs up to 200 feet high. This scarp thins out to the south near Point Providence on Peace River, and to the northwest in a wide sweeping arc near the mouth of the Big Buffalo River. The Alberta Plateau constitutes the main summering ground of the bison and is of some importance as a winter range.

At the foot of the escarpment lies a narrow plain, eight to ten miles in width, extending from Peace River in the south to about the 60th parallel, where it merges imperceptibly into the Little Buffalo-Slave River lowlands. It is characterized by large open prairies, meadows and muskegs, separated by typically narrow borders of willow-alder, aspen or spruce. The salt plains, southwest of Fort Smith, are a portion of this plain.

The lowest elevation is the alluvial

lowland which forms extensive wet meadows around Baril, Claire, and Mamawi Lakes and extends northward in a narrow strip along Slave River, including the Murdock Creek drainage. Outside the park, but within the main bison range, it broadens and becomes co-extensive with the Little Buffalo River lowlands and the northward extension of the salt plains. Most of this terrain is subject to flooding, and the dense stands of merchantable spruce which are often found on the natural levees along river and stream courses offer almost the only relief from the grassy meadow association. The lower two levels provide ideal winter range for the bison.

The census was planned for midwinter primarily to take advantage of the concentration on the winter ranges. It is fortunate from the point of view of detection and census that the winter ranges are the least wooded portions of the park. Another advantage is the sedentary nature of the groups and clans of bison in midwinter. The same herds were seen on the same or adjacent prairies over a time interval of several days. Since the count was completed in only ten days elapsed time there is little possibility that any herd was counted on two different strips.

The presence of a snow background was a great assistance in spotting the animals. Not only did they stand out more plainly, but the numerous tracks and trampled areas often gave a clue to their presence before the animals themselves were visible. Conversely, the absence of such signs precluded the necessity of further detailed search and freed the observer to devote his attention to more productive areas.

Ideal flying conditions were encountered. The air, being uniformly cold, was free of "bumps." Cloudless, sunny skies during the whole of the survey ensured maximum visibility. The sun was still at a low angle at the time of the count, however, so only the hours between ten A.M. and two P.M. were utilized, in order to get maximum definition.

OBSERVATIONS

Estimate of Numbers. In Wood Buffalo Park proper and the Little Buffalo-Slave River lowlands 3,263 bison were counted. The greatest concentration was found on the wet meadows between Baril Lake and the northwest bay of Lake Claire. Here, 729 bison were counted in a large loosely connected herd. Aerial and ground reconnaissance in this area had established that there was only one such aggregation. Since the census was based on the theory of one-quarter coverage, it was the original intention to multiply the number observed by four to arrive at an estimate of the total population. Obviously, a considerable error would have been introduced if this policy had been followed with respect to the above herd. To arrive at an estimate, therefore, the factor of four was used on the 2,534 other animals, and the 729 then added to give a total for this area of 10,865.

Reports from the Red River area, approximately 40 miles west of the Park, indicated the possibility of a herd of 350 in the vicinity. In a limited search between the Red and Wabiskaw Rivers 98 were located, and since there was an abundance of sign in this area as well as between the Red River and western park boundary, it is probable

that there are 400 bison roaming in suitable country almost as far west as Fort Vermilion. Most are south of Peace River but there is some sign on the narrow plain between Peace River and the Caribou Mountain to the north. The existence of a herd in this general area has been known since 1926.

Another herd has been reported in recent years in the vicinity of the Taltson River. It has apparently left the park permanently, since it has been seen both winter and summer. While servicing a fire crew in the summer of 1948, our pilot observed this herd on several occasions and estimated that it consisted of about 350 animals. It is interesting to note that this is near the route followed in 1772 by Hearne, who reported the Wood Buffalo common east of the Slave River (Soper, 1941).

It is well known that a few bison winter in scattered herds immediately east of the Slave. In flying to and from flight lines in the northern portion of the park some of this area was brought under observation and feeding areas were observed, although no animals were recorded. It is estimated that not more than 200 animals winter here, all of which return to the park for the summer.

For many years a small herd has been reported between the Athabasca River and Lake Claire as it made its way to winter grounds south of the park on the upper McIvor River. This herd was known to be south of the park at the time of survey, but on a later trip a group of about 30 was seen just southeast of Lake Claire.

These additional animals, outside the area systematically searched, total approximately 1,000, and thus the population on all the known bison range is estimated to be 12,000 animals.

Distribution. These results amply demonstrate the amount of concentration on the winter range pointed out by Soper (*op. cit.*) and others. It was found that 84 per cent of the animals observed were on the two lower levels of elevation described as the main winter range. This agrees well with Soper's estimate of 80 per cent, based on ground studies.

There have been two major extensions of range since 1934—the first, in the Taltson River area, has already been discussed. The second is in the Baril-Claire-Mamawi Lakes area, where four to five hundred were known to winter in 1934. It is estimated that there were 3,300 in this region in February, 1949.

It is interesting to note that the region between Jackfish Creek and the foothills of the Caribou Mountains has been reoccupied to some extent, as Soper predicted in 1934. The region immediately west of Lake Claire, which was also unoccupied in 1934, is still definitely understocked.

Percentage of Calves. The calf ratio obtained in this study is based on a differential count of 46 groups ranging in size from two to 34 animals. Twenty-five of the groups recorded contained no calves; the 21 other groups had from one to three each. There were 323 animals in the sample (approximately ten per cent of the total number observed), of which 26 were calves. Thus, the ratio of calves to all older animals, in February, 1949, was approximately 1:12 or about eight per cent.

Soper obtained a calf ratio from a study of 697 animals, of which 92 were calves, giving a proportion of 1:6.5 or

15 per cent. Since this figure was based on groups selected because of the presence of calves, it cannot be directly compared with the figure stated above. It is comparable, however, to a ratio derived from the 21 groups in our study which were accompanied by calves. In these selected groups the number of older animals observed was 173, the number of calves 26, and the ratio 15 per cent. This would indicate at least that conditions affecting the production and survival of calves in 1948 and 1932–34 were similar and that this figure probably remains fairly constant.

DISCUSSION

Compared with previous estimates the figures obtained in the present survey are lower than would be expected. If there were 300 head in 1897, a net annual increase of only seven per cent could have produced the 1,500 estimated by Graham in 1922. Continued increase at this rate, plus a reasonable allowance for introduced animals, could have produced a population in 1934 of 10,000 to 12,000 which agrees closely with Soper's estimate. On this basis the present population should be at least 25,000.

On the other hand, the present maximum rate of increase as shown by the proportion of calves is about eight per cent. From this must be subtracted mortality from all causes, such as organized slaughter, diseases, predation, and accidents, so that the net rate of increase is almost certainly less than seven per cent. Some evidence already presented indicates that a similar situation may have existed from 1932 to 1934 and may well be the normal condition.

All observers between 1895 and 1900 agreed that the bison population was low and their estimates were consistently less than 500. Graham based his estimate on a brief examination of the bison range during which he actually saw only 114 animals. Soper had ample time to become thoroughly familiar with the range but was restricted in his movements by the difficulties of travel on the ground. There is a wide discrepancy between his estimate of 12,000 and the 1931 aerial count of less than 1,400.

From the limited evidence available it now appears that estimates based on ground studies have exceeded the mark and aerial counts have been too low. Soper felt that an allowance of 25 per cent should be made for animals which were hidden in the timber and thus not counted. If he was correct, there may be as many as 15,000 bison on the northern ranges. Soper's allowance is considered generous by the present writer so that the 1949 population is thought to be between 12,000 and 15,000.

The population trend is considered to be equally as important as the absolute population at any point of time. The calf ratio and the gradual extension of range previously discussed are evidence of a slow increase in numbers. It was hoped that a comparison between the present count and the one made by Oldham (1947 unpublished) would give a more quantitative picture but this was not the case. Oldham had no second observer, yet he attempted to cover a wider strip; his count was made earlier in the winter (late December and early January); he used a slower aircraft; and he changed the direction of some of his

strips from east and west to north and south. These are major variations, almost impossible to evaluate.

The chief sources of error in the present method lie in estimating the degree of coverage actually attained and the proportion of the animals missed in wooded areas. Small errors in these factors may give rise to a considerable error in the final estimate. If, however, the technique is held constant on future counts, the numbers of animals observed should be directly comparable and a means be thus provided of following any changes in the population which may occur.

SUMMARY

(1) An aerial strip census of the bison in and adjacent to Wood Buffalo Park was carried out in February 1949, using a De Havilland "Beaver" and a Fairchild "71C," pilot, and two observers. Lines were flown every eight miles and all animals within one mile of either side of the flight line were recorded, thus giving a strip two miles wide and 25 per cent coverage. A cruising speed of 120 mph and altitude of 2,000 feet were found to be satisfactory. The cost was less than ten cents per square mile.

(2) On the regular flight lines 3,263 bison were counted, and in a special search 98 more were seen. It is estimated that the total population is at least 12,000 and probably not more than 15,000. Previous estimates are reviewed and it is suggested that ground parties have over-estimated and aerial surveys have under-estimated the population.

(3) A gradual extension of range into previously occupied and abandoned areas both in and out of the preserve was observed and described.

(4) The calf ratio was determined from a differential count of 46 groups containing 323 individuals and was found to be eight per cent. The net rate of increase is not known but is considered to be less than eight per cent.

(5) The aerial method is believed to be the only practical means of making a census of the larger mammals in wilderness terrain. The technique described for bison is quick and relatively inexpensive and is believed to be adequate as a means of estimating the size of the herd and following the trends in population.

LITERATURE CITED

GRAHAM, MAXWELL. 1923. Canada's Wild Buffalo. Canadian Department of the Interior.

OLDHAM, E. G. 1947. Report on the Buffalo count, Wood Buffalo Park (Unpublished).

PREBLE, E. A. 1908. A biological investigation of the Athabaska-Mackenzie region. U. S. Dept. Agr. N. Am. Fauna No. **27**: 143–150.

SOPER, J. DEWEY. 1939. Wood Buffalo Park; notes on the physical geography of the park and vicinity. Geog. Rev. **29**: 383–399.

———. 1941. History, range, and home life of the northern Bison. Ecol. Monogr., **11**: 347–412.

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IDENTIFYING NESTS OF THE ANATIDAE OF THE CANADIAN PRAIRIES

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Duck nests typically are lined with many down feathers and some breast feathers. This soft mass also forms a concealing and protective cover for an unattended nest. Since both breast feathers and down exhibit differences characteristic of species, they provide a definite means of nest identification. This article includes natural size photographs, also a key, based on the dual system of feathers and down, for identification of wildfowl nests on the prairies of Manitoba, Saskatchewan, and Alberta. The only species regularly nesting on these prairies and not included herein is the Canada Goose, whose down is far larger than that of any species illustrated in this article.

Acknowledgements

This study was done while I was a Helen Gates Putnam Fellow in Animal Conservation at Vassar College. I am especially grateful to Dr. Ralph S. Palmer, now of the New York State Museum and State Science Service, for advice and supervision, and to Mr. John Heller, also of the New York State Museum, for making the photographs. Down and feather samples were received from: Mr. A. F. Anderson of Manitoba; my father, Mr. Charles Broley of Delta, Ontario; Mr. J. L. Peters of the Museum of Comparative Zoology at Harvard; Mr. Howard L. Mendall of the Maine Cooperative Wildlife Research Unit; and Dr. Alexander Wetmore, Secretary of the Smithsonian Institution.

Literature Review

Most of the down feathers found in the nests of at least many of the Anatidae apparently are rather unique, being an especially long and strengthened type, acquired before the nesting season. Millais (1902: 27) noted that in the female Mallard the breast feathers were darker after late spring. Jackson (1915: 35) stated: "Perhaps the most interesting fact I have to record is that female surface-feeding ducks in spring have a complete body-moult, the tail and inner secondaries also being involved. The down, too, is shed and replaced by the usual down, and in addition by a luxuriant down much longer and coarser than the ordinary down. Mr. Millais has apparently overlooked both these moults, and there seems to be no mention of them in the literature. The fact that the female Long-tailed Duck [Oldsquaw] moults its whitish winter down and acquires just before the breeding-season an almost black down was first discovered by Dr. E. Hartert, who told me about it. Subsequently I discovered that the females of the surface-feeding ducks and those of the genus *Nyroca* also acquired a special down just before the breeding season. . . . This down is evidently used for embedding the eggs in during incubation, and has been designated 'nest down' by Dr. Hartert, a term I propose to use in describing it."

Independently of Jackson in Britain, Bowles (1917: 206) in the United States noted that "The down seen in nests of

the Mallard . . . found in April and May is many shades darker than the down of birds of this species shot in October, November, and December." He pointed out that such seasonal variation exists in several other species.

Hartert (1917: 370), replying to Bowles, confirmed Jackson's observations, stating: "I believe that all palaearctic Ducks, or at least the majority of them, have a down-moult in spring, but in some species the colour is the same, though the nest-down is often longer and coarser than the ordinary down."

That the breast feathers and down of ducks can be used to identify the nest-builder is not a new idea. It has been discussed at intervals in British literature for over 80 years. Noble (1908: 18) mentioned three methods of identification, by means of: (1) eggs, (2) nest down, and (3) feathers which generally are mixed with down. He stated: "The last provides by far the most important and certain means of identification, although it is seldom mentioned by writers on this subject." Jackson (1918: 98) stated that " . . . it is, I consider, impossible to identify a nest lining . . . by examination of the down alone, and that the feathers are by far the most important means of identification." The *Handbook of British Birds* (volume 3) figures, natural size, breast feathers of nearly all British Anatidae. Bent (1923 and 1925) described the nest down and breast feathers of many North American Anatidae, at least in a general way, but this subject usually has been neglected in American literature.

USES AND LIMITATIONS OF KEY

Practical applications of this method of identifying duck nests are obvious. Even if the ducklings have departed, the nest-builder can be identified by a sample of the nesting material. Also, time spent in trying to identify elusive ducks can be saved by following the same procedure. Furthermore, by quickly taking a sample of nesting material and departing from the vicinity (in cases where the census taker cannot readily identify a nest with eggs) the location of the nest is less advertised to predators. Of course, if a sample of material is taken, any exposed eggs should be covered before the collector departs.

Certain complications may arise in identifying duck nests. One is the possibility of finding the nest of a hybrid duck whose feathers and/or down do not fit the key in this paper. Also, there may be more color variation in some species than I have indicated in the key, but it is difficult to describe adequately such variations. A duck may nest on a site used by another species the previous year and some old material perhaps might remain to mingle with the new lining. In the case of hole-nesting ducks, woodpecker feathers may occur with the duck feathers. With a little practice, however, and using both key and plates, an investigator soon should be able to make rapid and accurate identifications in nearly every instance.

An occasional nest devoid of any down may be found. The writer has seen only one such nest, that of a Pintail. Noble (1908: 23) and Compton (1908) stated that a few Mallard nests

observed in Britain lacked down. I know of no similar American cases but probably they exist. It is also possible that the down used in a second attempt at nesting might not be typical nest down, but I have not been able to investigate this matter.

GENERALIZED GROUPINGS OF DUCK NESTS

The tree-nesting species included in the key all have white or very light-colored down and breast feathers, i.e., American and Hooded Merganser, Wood Duck, Bufflehead, Barrow's Goldeneye, and American Goldeneye. The down is light-colored also in the Ruddy Duck and Redhead, but the breast feathers are dark. Omitting tree-nesters, the others can be divided roughly according to the total amount of nest lining in *completed* nests. The following have much lining: American Eider, Canvasback, Redhead, the Scoters, Black Duck, Mallard, and Shoveller. The following have relatively little lining: the Teals, Pintail, the Scaups, Ring-necked Duck, and Ruddy Duck. Other species form an intermediate group. Since the nest lining is added gradually as laying and incubation proceeds, an unfinished nest may not fall in the proper group as here outlined.

SUGGESTIONS TO COLLECTORS

Anyone doing much nest census work would do well to make a collection of down-and-feather samples. It is not desirable merely to pluck samples from dead birds; when down is taken from the nest it has more 'aliveness' and springy vitality and one is certain of getting material from the proper plumage. Dirt, dust, and plant material usually are mixed with the samples and must be eliminated. The author has found that a room without drafts, a needle to separate feather barbs, and considerable patience are essentials for this work. Harvie-Brown (1906) has discussed the subject of preparing and examining down samples at some length.

Down and feathers may be mounted by inserting them between two ordinary 3 ×4 inch lantern slide cover glasses, which then are bound together securely with adhesive tape. A mount should include: (1) a breast feather, or more than one feather if there is marked variation as in the Mallard; (2) a single down feather; and (3) an aggregate of a number of down feathers to demonstrate the appearance of down in bulk.

A mount of feathers and down often appears surprisingly different when viewed over a light background than when viewed over a dark one. Some characteristics show much better one way than the other. For the sake of uniformity, a dark background was used in photographing the mounts for the accompanying plates, even though some characters might otherwise have been shown in somewhat better fashion.

KEY

I. Down wholly white
  A. Vane of breast feather wholly white
    1. Shaft of breast feather white (Plate 13, A) ..... American Merganser
    2. Shaft dark (Plate 13, B) ..... American Goldeneye

B. Vane of breast feather not wholly white
1. Vane of breast feather white with wide brown tip (some wholly white breast feathers present also); only species in key where some down may have brown tip (Plate 13, C) ..... Barrow's Goldeneye
2. Breast feather brown with white tip
a. Down when flattened shows dense white 'center'; down and breast feather small; darkened portion of shaft breast feather darker than adjacent vane (Plate 13, D) ..... Ruddy Duck
b. Down without dense white 'center'; down and feather large; darkened portion of shaft of breast feather same as adjacent vane (Plate 13, E) ..... Redhead

II. Down not wholly white
A. Vane of breast feather mainly white (white at distal end; basal downy portion light grayish-beige)
1. Pigmented portion of down feather very light beige
a. Breast feather wide (Plate 13, F) ..... Wood Duck
b. Breast feather narrow
(1). Proximal portion of shaft of breast feather light; distal portion of shaft dark (Plate 14, A) .. Hooded Merganser
(2). Proximal portion of shaft breast feather dark (Plate 14, B) ..... Bufflehead
2. Pigmented portion of down feather darker beige
a. Down feather with small white 'center'; down feather relatively large; proximal portion of shaft of breast feather dark (Plate 14, C) ..... Red-breasted Merganser
b. Down feathers (in bulk) half beige, half white; down diffuse white 'center'; down feather relatively small; shaft of breast feather light (Plate 14, D) ..... Green-winged Teal
B. Vane of breast feather not mainly white
1. Vane of breast feather of fairly uniform brown coloration without conspicuous marking
a. Vane of breast feather dark, large, and without noticeable gradation in color, often with light area at sides; down large and very dark (Plate 14, E) .... Black Duck
b. Vane of breast feather with noticeable gradation lengthwise in color
(1). Vane of breast feather becoming rather abruptly dark at tip; proximal portion light brown; feather small (Plate 14, F) ..... Surf Scoter
(2). Vane of breast feather light at base with gradual gradation to darker terminal portion (Plate 15, A) ..... White-winged Scoter
2. Vane of breast feather with conspicuous markings
a. Vane of breast feather dusky with definite light terminal band and no other markings
(1). Total shaft of breast feather dusky
(a). Dark portion of breast feather evenly colored; narrow white tip; almost no white in down feather (Plate 15, B) ..... Greater Scaup Duck
(b). Dark portion of breast feather unevenly colored
i. Darkest portion of breast feather adjacent to terminal white band (Plate 15, C) ..... Ring-neck Duck
ii. Dark portion of breast feather shades gradually into wide white terminal band (Plate 15, D) ..... Lesser Scaup Duck
(2). Proximal third of shaft of breast feather light; distal portion darker
(a). Demarcation of dark area and light tip of breast feather vane a fairly straight transverse line; down feather with inconspicuous light tips (Plate 15, E) ..... Canvasback

(b). Line of color demarcation decidedly curved
i. Dark area of breast feather mottled; down feather with very conspicuous tips (Plate 15, F)..... Widgeon
ii. Dark area of breast feather darkest in center; down feather with inconspicuous white tips (Plate 16, A)..... Gadwall

b. Vane of breast feather with conspicuous markings irrespective of tip characteristics
(1). Vane of breast feather with conspicuous dark central area surrounded on at least 3 sides with light marginal area
(a). Vane of breast feather with dark circular subterminal area (Plate 16, B)..... Shoveller
(b). Vane of breast feather with dark elongated subterminal area
i. Down feather with conspicuous white 'center' and dark tips; proximal portion of breast feather very light (Plate 16, C)..... Blue-winged Teal
ii. Down feather with inconspicuous white 'center'; down feathers appear (in bulk) almost evenly colored throughout; no white in vane of breast feather (Plate 16, D)..... Pintail
(2). Vane of breast feather with alternating bars or a dark triangular area
(a). Either alternating bars of dusky and very pale buff or with more or less triangular area coming to point at distal end of shaft (Plate 16, E)..... Mallard
(b). Alternating bars; of light and dark brown (Plate 16, F)..... American Eider

LITERATURE CITED

BENT, A. C. 1923. Life histories of North American wild fowl. U. S. Nat. Mus. Bull. 126, Washington, D. C.

———. 1925. Life histories of North American wild fowl. U. S. Nat. Mus. Bull. 130, Washington, D. C.

BOWLES, J. H. 1917. Coloration of down in adult ducks. Auk, **42**: 206–207.

COMPTON, M. W. 1908. Want of down in mallards' nests. Brit. Birds, **2**: 62.

HARTERT, E. 1917. [Coloration of down in adult ducks.] Auk, **34**: 370.

HARVIE-BROWN, J. A. 1906. Identification of wild ducks' downs. Zoologist, 4th ser.. **10**: 370–374.

JACKSON, ANNIE C. 1915. Notes on the moults and sequence of plumages in some British ducks. Brit. Birds, **9**: 34–42.

———. 1918. The nest down of some British ducks. Brit. Birds, **12**: 98–100.

NOBLE, H. 1908. Identification of ducks' eggs. Brit. Birds, **2**: 18–23.

MILLAIS, J. G. 1902. The natural history of the surface feeding ducks. London.

Accepted for publication March 1, 1950.

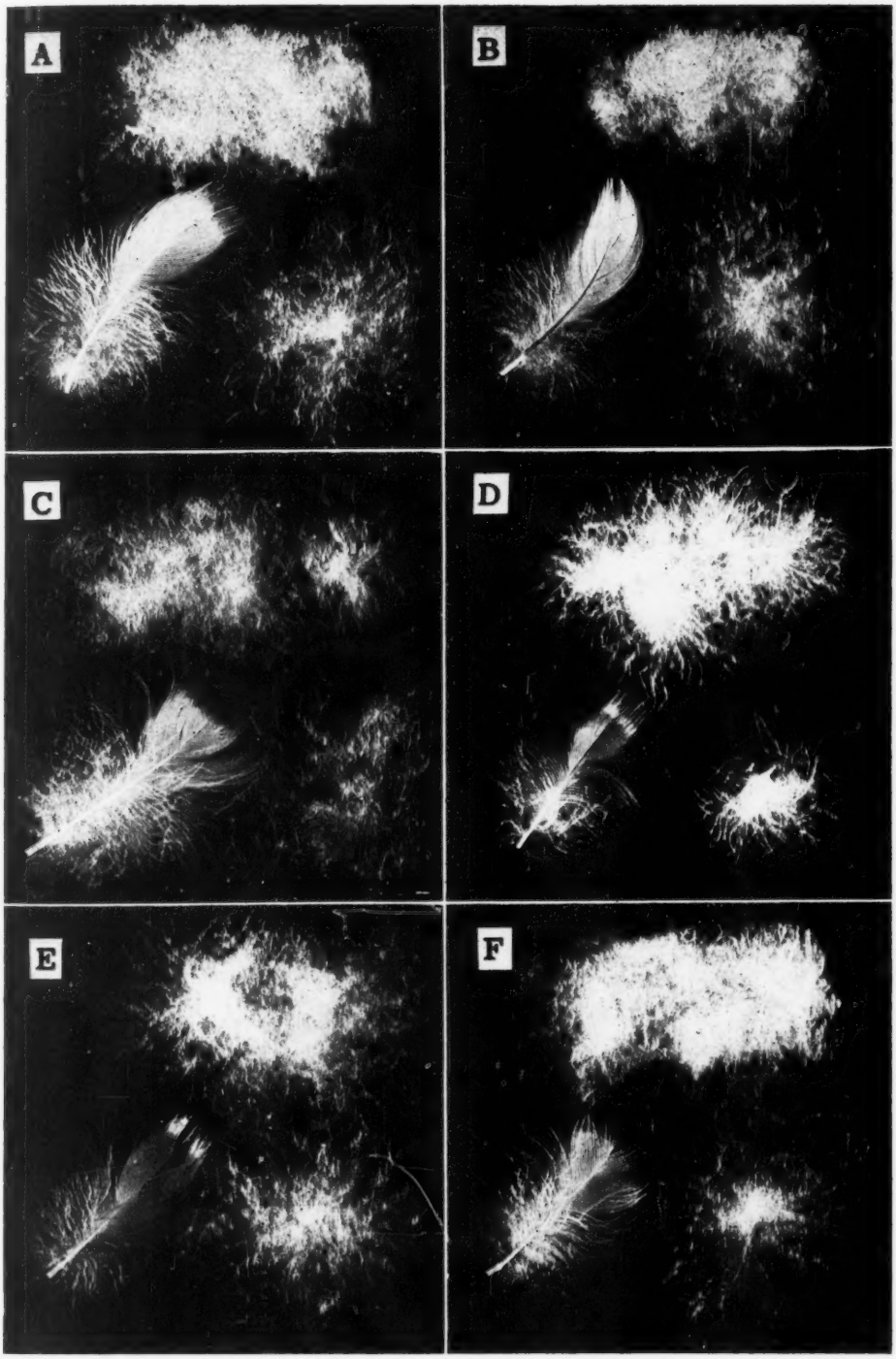

PLATE 13. Down and breast feathers, life size. A. American Merganser. B. American Goldeneye. C. Barrow's Goldeneye. D. Ruddy Duck. E. Redhead. F. Wood Duck.

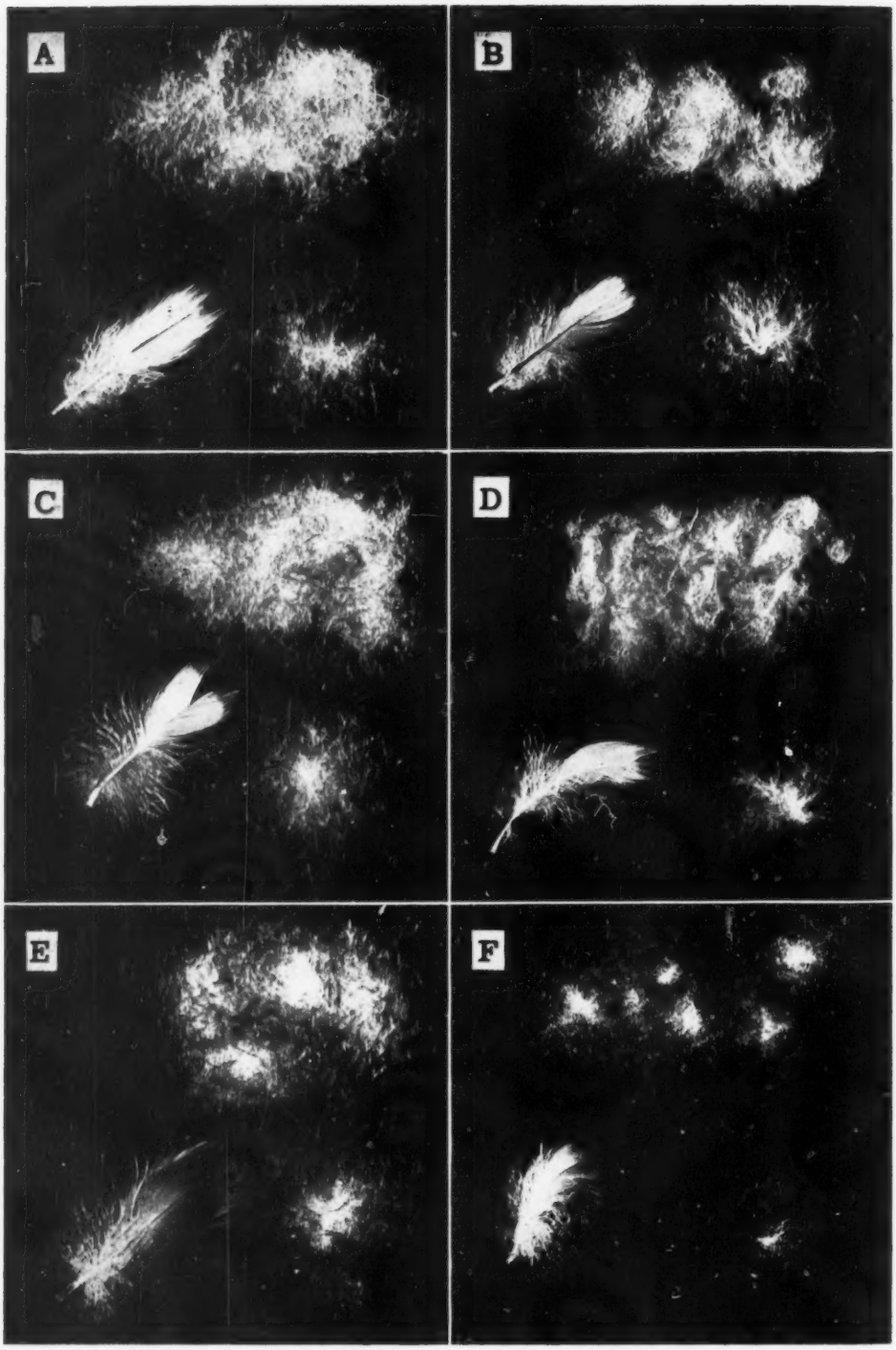

PLATE 14. Down and breast feathers, life size. A. Hooded Merganser. B. Bufflehead. C. Red-breasted Merganser. D. Green-winged Teal. E. Black Duck. F. Surf Scoter.

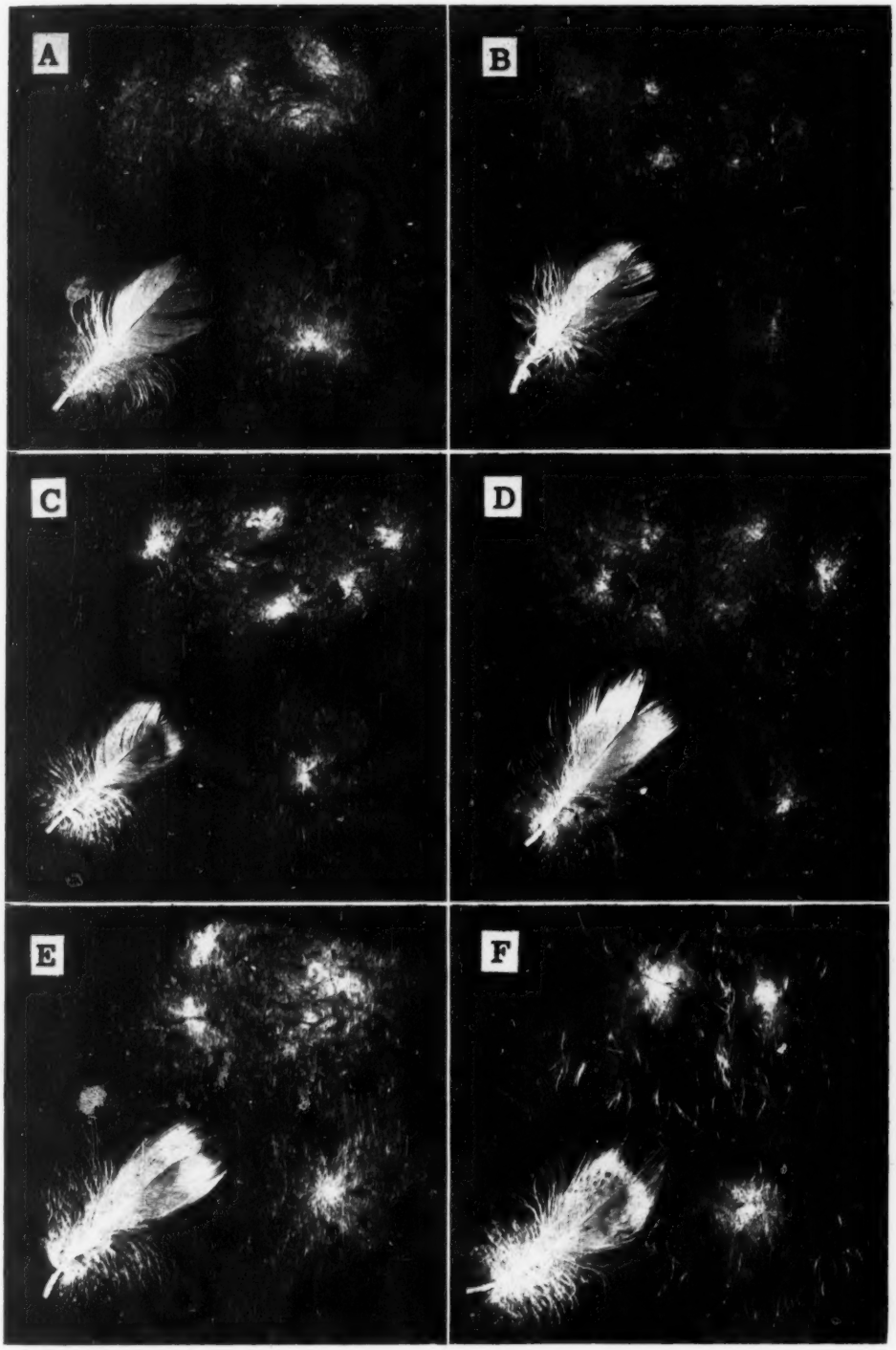

PLATE 15. Down and breast feathers, life size. A. White-winged Scoter. B. Greater Scaup Duck. C. Ring-necked Duck. D. Lesser Scaup Duck. E. Canvasback. F. Widgeon.

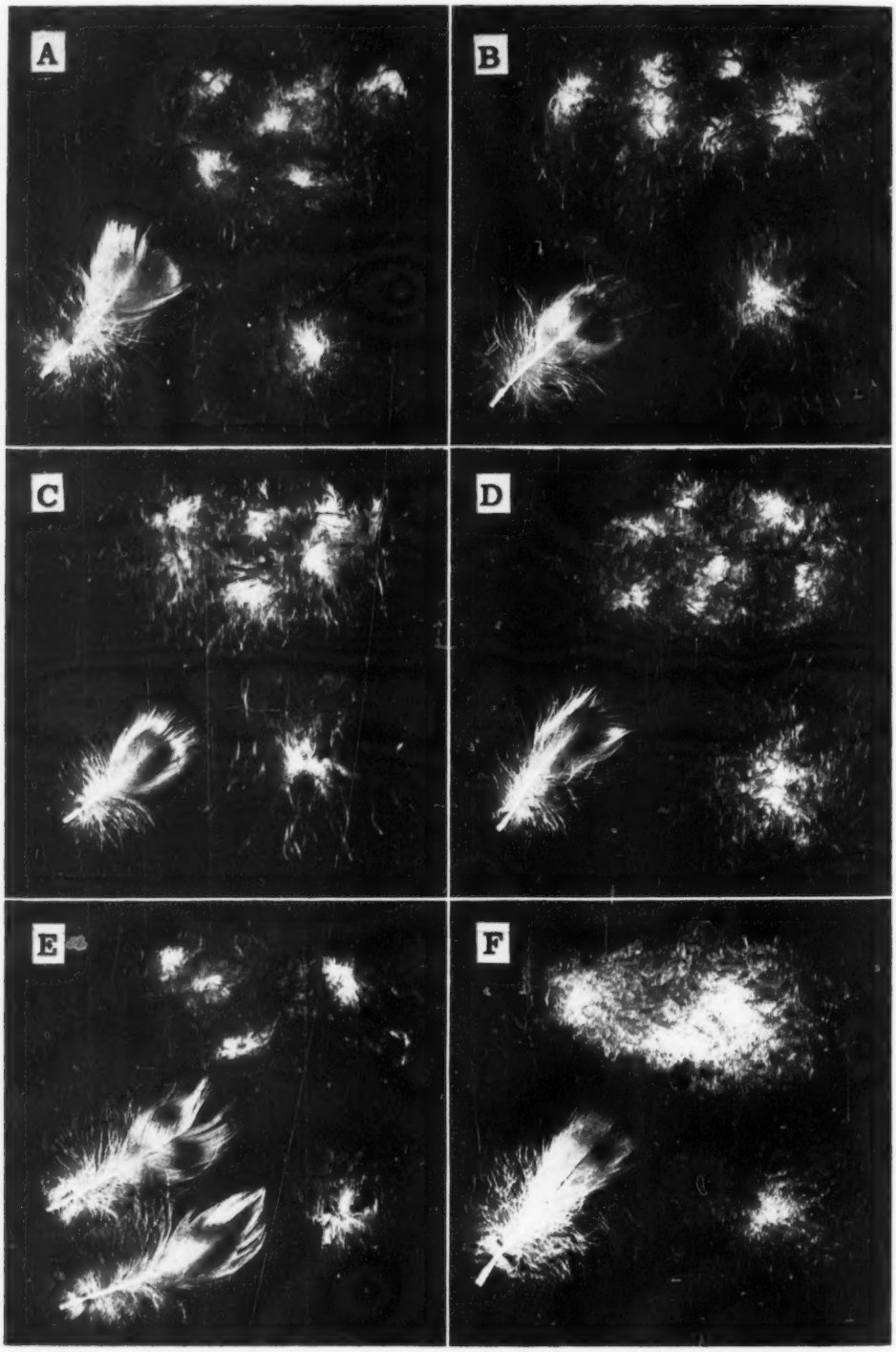

PLATE 16. Down and breast feathers, life size. A. Gadwall. B. Shoveller. C. Blue-winged Teal. D. Pintail. E. Mallard. F. American Eider.

BREEDING SEASON, PRODUCTIVITY, AND FAWNING PERIOD OF THE MULE DEER IN UTAH[1]

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Introduction

Published material relative to the breeding period, reproductive potential, fawning period, and related information for the Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) in Utah is not abundant. The material available is of a fragmentary nature and is widely scattered but of value to the managers of the mule deer herds. Knowledge of the breeding period makes it possible to establish hunting seasons which will cause a minimum of disturbance during that important time. A study of the average number of embryos per doe is invaluable as a guide to the fertility of the species. Prenatal sex ratios supply information as to the primary sex ratio for the species and are helpful to a better understanding of the mortality suffered by reason of a change in the proportion of the sexes. Many other data useful in the management of the mule deer can also be secured from such a study.

For a number of years pregnancy records have been secured from mule deer found dead in Utah. These deer have died from a variety of causes. Many were the victims of automobile or railroad accidents, others the result of control measures, a few were collected for scientific purposes, and still others died from malnutrition and other causes. During the winter of 1948–49 the deer along the Wasatch Front from Nephi northward to the Idaho line suffered heavy losses as a result of the long, cold winter and heavy snows which restricted them to a narrow belt of already badly overutilized winter range. This resulted in the death of a relatively large number of deer, thus making specimens available to the writers for examination. The results of the combined data are given in the following discussion.

Breeding

Breeding Season.—The breeding season of mule deer in Utah is generally considered to include the month of November and the first half of December. Bucks killed during the latter part of the hunting season (the last third of October) occasionally have swollen necks indicating they are approaching the breeding season. Two methods have been used in the present study to establish the extent of breeding season more accurately: (1) aging embryos

[1] These studies were a part of the Utah Cooperative Big Game, Livestock, and Range Relationship Research Project conducted jointly by the Utah State Fish and Game Commission, U. S. Forest Service, U. S. Fish and Wildlife Service, and Utah State Agricultural College. The writers wish to acknowledge the assistance of Forrest S. Romero, former assistant on the project, and of D. M. Gaufin, Wallace Jensen, Saunders M. Clark, Rulon K. Francis, Roy Garrard, Harry B. Lyman, Claude MacFarland, Othello Riley, and Wm. N. Jacklin all of the Utah State Fish and Game Commission; also numerous other people who assisted in many ways. Without their kind help and cooperation many of the data would not have been available.

from does whose date of death was known and calculating back to the date of conception; and (2) using the estimated ages of tagged fawns to determine the birth dates and then figuring back to the dates of conception.

A total of 43 pregnant does with embryos large enough to measure, and whose date of death could be determined were available for this compilation. The embryos were measured from the crown to rump and this measurement was then applied to the white-tailed deer growth curve of embryos of Cheatum and Morton (1946) to determine the age. Since a different species of deer was under consideration there was some question as to how accurately the white-tail growth curve would age mule deer embryos. However, New York white-tailed deer and Utah mule deer are of approximately the same size and the curve was thought to be applicable. Chattin (1948) also used the white-tailed deer growth curve of embryos to age a group of Rocky Mountain mule deer embryos from the Interstate Deer Herd of northeastern California and south central Oregon. To check further on this matter, the growth weight curve to age sheep embryos (Winters and Feuffel, 1936) was converted to a deer basis. It was assumed that the curve of the fetal weight increment of sheep and deer would be nearly the same. The deer data when based on

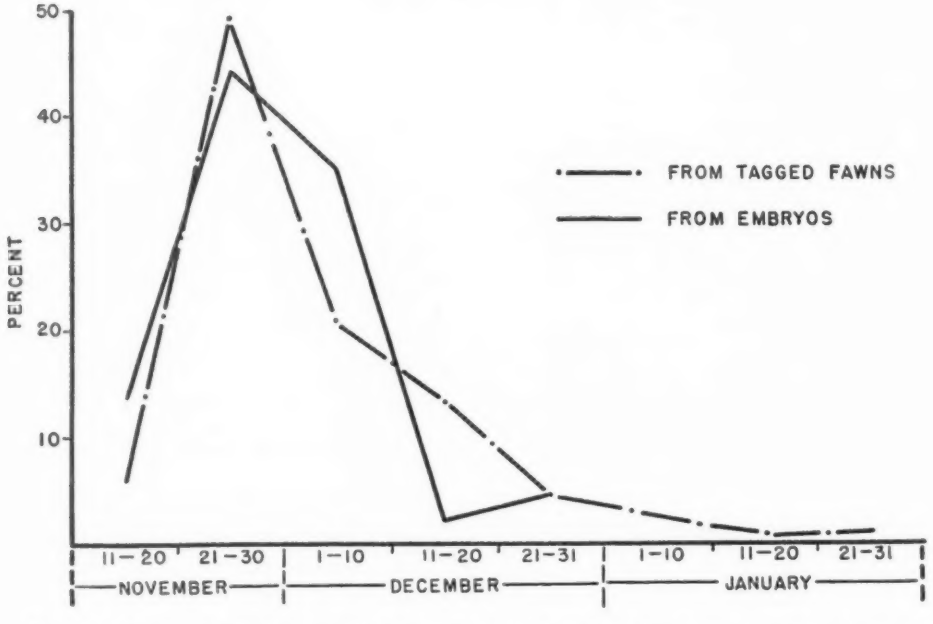

FIG. 1.—Seasonal distribution of breeding in Utah mule deer from: length of embryos from 43 deer, the ages of which were computed from whitetail embryo curve of Cheatum and Morton (1946); and from use of mule deer gestation period and estimated ages of 232 fawns which have been captured and tagged.

the sheep weight curve gave essentially the same results as were obtained from the white-tailed deer crown-rump measurement curve. The embryos were therefore aged by means of the white-tailed deer growth curve. From this information the dates when the does conceived was determined, the data plotted, and a curve was drawn as in Figure 1.

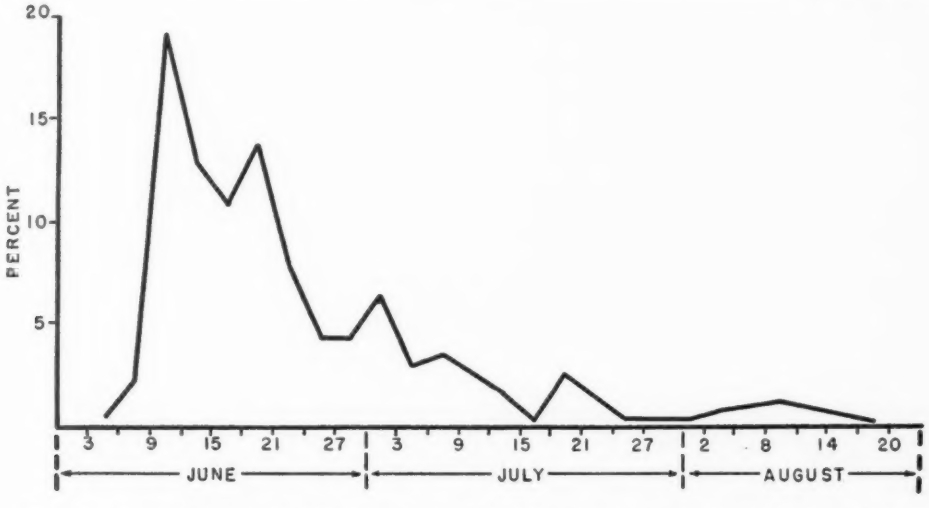

FIG. 2.—Fawning period of Utah mule deer as determined from estimated ages of 232 fawns which have been captured and tagged.

Figure 1 shows that breeding started the middle of November, rose sharply to a peak during the last 10 days of the month, fell off a little the first 10 days of December, dropped off sharply and finally ended the last of the month.

The estimated age of 232 fawns captured for tagging has been secured in central Utah during the last few years (Figure 2). By determining the birth dates, using the average gestation period, and calculating back, the probable periods when the does conceived were determined as presented in Figure 1. This period extended from the first third of November to the last of January. It was determined that 61 per cent of the 232 calculated breeding dates fell within the 13 day period from November 20 through December 2.

A few additional observations have been made which indicate that does are occasionally bred as early as the last of October. George Hunter of Richfield, Utah told the senior author of having seen a buck covering a doe during late October of 1936 or 1937. A similar observation was made by George Prouse of Kanosh, Utah on October 31, 1939. In addition, Floyd A. Thompson, U. S. Game Management Agent, killed a pregnant doe with a single embryo about one inch in length on November 30, 1947 during a special hunt south of Nephi, Utah. Reference to the growth curve of the white-tail embryos (Cheatum and Morton, 1946) indicated that this doe was probably bred in the

latter part of October. Four instances of bucks covering does have been observed by the writers, the dates of these observations being on November 23 and 28 and on December 3 and 12.

A résumé of the available data reveals a mule deer breeding season in Utah starting the very last few days of October and rising to a peak near the end of November. By mid-December breeding activities decline perceptibly although a limited amount of breeding takes place even to the end of January.

The breeding season of the Interstate Deer Herd of California and Oregon has been investigated. Chattin (1948) reporting on the age of embryos from 43 mule deer, found that breeding started November 14–17, peaked from November 30–December 3 and gradually declined until January 1–4. This peak breeding period was essentially the same as that for Utah; however, the Utah season was found to start over two weeks earlier and extended approximately two weeks later.

Breeding in Relation to Age.[2]—The minimum age at which mule deer will breed has not been thoroughly investigated. Nichol (1938) states that corralled Rocky Mountain mule deer bucks and does bred in Arizona when approximately 18 months old. This appears to be the generally accepted breeding age. Additional information which was secured on this subject is as follows.

Some mule deer males apparently reach sexual maturity during their first fall. Orange A. Olsen in a memorandum for the files of the U. S. Forest Service at Ogden, Utah, dated September 24, 1941, reported that a buck born in 1940 bred a 19-month-old doe about February 1, 1941, when the buck was only 7 months old. The doe gave birth to a single fawn August 19, 1941. This occurred at the State Game Farm at Springville under confinement. Thus it would seem that some of the June-born buck fawns would be capable of serving does during the latter part of the following season. However, general field observations reveal that buck fawns exhibit scarcely any interest in does during the rut. Therefore, even though a few may be sexually mature, their role as breeders must be slight. The yearling males display a moderate amount of interest in the does but are subjugated by the older bucks. It is probable that they play a more important role during the latter part of the rut when many of the older males are worn down from breeding activity and have lost interest in the does. Bucks 2 years old or older are keenly interested in the does and the extent of their mating appears to depend largely on their physical ability to claim does and to fend off competitors.

As previously indicated, Nichol (1938) found that Rocky Mountain mule deer does first breed when about 18 months old. During this study some additional information was secured on this point. No pregnancies were found in a group of 18 fawns which were

[2] The deer were aged by the development and wear of their teeth as described by Rasmussen (1939). Additional deer skulls of known age were also available to the writers for reference in aging the animals. The deer were placed in various classes as follows:

Fawn —animals less than 1 year of age.
Yearling—animals from 1 to 2 years of age.
2-Year —animals from 2 to 3 years of age.
Prime —animals from 3 to 8 years of age.
Old —animals 8 years and older.

examined. However, this was not a true sample since many of them had died of malnutrition. Malnutrition tends to take the weaker, less robust fawns, and the vigorous ones which would probably be the breeders, are the ones least likely to succumb. To check further on this problem, efforts were made at the deer-checking stations to learn whether the does were wet, i.e., whether they had nursed fawns the previous season, or whether they were dry. It is common practice to remove the udder of wet does killed during the hunting season in Utah and Nevada, but on dry animals with little or no udder development, such as fawns and yearlings or older does which had no fawns during the year, it is left on the carcass when dressed, thereby indicating whether the doe was wet or not. By means of this indicator and by interrogating the hunters about the condition of the udders, some additional information on pregnancy was secured. Of 118 yearling Utah does (about 16 months old) two were reported as being wet. At Duck Creek, Nevada, 1 of 20 yearling does was considered to be wet. Thus, 3 (2.2%) of 138 yearling does checked probably had young when they were a little over one year of age, therefore conceiving as fawns when only about 6–8 months of age.

There are a few references in the literature regarding the breeding age of the black-tailed deer, which is closely related to the mule deer. Shantz (1943) reported that two black-tailed doe fawns were raised in partial captivity on the Siskiyou National Forest in Oregon. The following spring each bore young when she was approximately one year of age. Rampont (1926) likewise reported a California black-tailed doe 15 months of age giving birth to a single fawn. In New York, Morton and Cheatum (1946) found 36.2 per cent of the white-tailed deer fawns from the southern part of the State to be pregnant. In contrast only 4.2 per cent of the fawns from the northern part of the State, where food and other environmental factors were less favorable were pregnant.

A total of 316 does dying from various causes has been examined for pregnancy during this study. Of this group, several were rejected for various reasons and only 288 were used in compiling the pregnancy data. Only those checked after January 1 are being considered in this paper, since those examined earlier may have had embryos too small to be found by gross examination. Even so, a small percentage of does are bred after January 1 as evidenced in Figure 1 and possibly a few pregnancies were missed. Only about 10.0 per cent of the deer were checked prior to February 1. The fawn tagging dates indicated that about 7.0 per cent of the fawns were conceived during January. Therefore, the maximum error which could be expected in the pregnancy data by reason of including January information would be less than 1.0 per cent (10.0 per cent of 7.0 per cent). For the January records it is doubtful if much error resulted because of missing January or late December conceptions since only 6.0 per cent of the does examined during January were barren or without fetuses as contrasted to 14.6 per cent for all does checked.

The does examined were separated as to cause of death, i.e., causes other than malnutrition (Table 1), death due to

TABLE 1.—PREGNANCY DATA BY AGE CLASSES OF DOES DYING FROM CAUSES OTHER THAN MALNUTRITION

Age Classes of Does	Does		Embryos										
			Singles		Twins		Triplets		Barren		Total No.	Per Cent Does Pregnant	No. Embryos per Doe
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent			
Yearlings	14	21.9	5	35.7	3	21.4	—	—	6	42.9	11	57.1	0.78
2-Years	6	9.4	4	66.7	2	33.3	—	—	—	—	8	100.0	1.33
Prime	28	43.7	7	25.0	18	64.3	2	7.1	1	3.6	49	96.4	1.75
Old	16	25.0	7	43.8	6	37.5	—	—	3	18.7	19	81.3	1.19
Unclassified	37	—	19	51.4	16	43.2	—	—	2	5.4	51	94.6	1.38
Total or Average	101	100.0	42	41.6	45	44.5	2	2.0	12	11.9	138	88.1	1.37

TABLE 2.—PREGNANCY DATA BY AGE CLASSES OF DOES DYING FROM MALNUTRITION

Age Classes of Does	No.	Per Cent	Embryos										
			Singles		Twins		Triplets		Barren		Total No.	Per Cent Does Pregnant	No. Embryos per Doe
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent			
Yearlings	64	30.9	23	35.9	1	1.6	—	—	40	62.5	25	37.5	0.39
2-Years	30	14.5	11	36.7	17	56.6	—	—	2	6.7	45	93.3	1.50
Prime	61	29.5	16	26.2	39	63.9	1	1.7	5	8.2	97	91.8	1.59
Old	52	25.1	22	42.3	25	48.1	—	—	5	9.6	72	90.4	1.38
Unclassified.....	2	—	1	50.0	—	50.0	—	—	—	—	3	100.0	1.50
Total or Average	209	100.0	73	34.9	83	39.7	1	0.5	52	24.9	242	75.1	1.16

TABLE 3.—PREGNANCY DATA BY AGE CLASSES OF DOES DYING FROM UNDETERMINED CAUSES

Age Classes of Does	No.	Per Cent	Embryos										
			Singles		Twins		Triplets		Barren		Total No.	Per Cent Does Pregnant	No Embryos per Doe
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent			
Yearlings	1	25.0	—	—	—	—	—	—	1	100.0	0	0	0
2-Years	—	—	—	—	—	—	—	—	—	—	—	—	—
Prime	3	75.0	—	—	2	66.7	—	—	1	33.3	4	66.7	1.33
Old	—	—	—	—	—	—	—	—	—	—	—	—	—
Unclassified	2	—	1	50.0	1	50.0	—	—	—	—	3	100.0	1.50
Total or Average	6	100.0	1	16.7	3	50.0	—	—	2	33.3	7	66.7	1.17

TABLE 4.—PREGNANCY DATA OF ALL DOES DYING FROM ALL CAUSES

Age Classes of Does	No.	Per Cent	Embryos										
			Singles		Twins		Triplets		Barren		Total No.	Per Cent Does Pregnant	No. Embryos Per Doe
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent			
2-Years	36	14.3	15	41.7	19	52.8	—	—	2	5.5	53	94.4	1.47
Prime	92	36.7	23	25.0	59	64.1	3	3.3	7	7.6	150	92.4	1.63
Old	68	27.1	29	42.6	31	45.6	—	—	8	11.8	91	88.2	1.34
Total and Average	196	78.1	67	34.2	109	55.6	3	1.5	17	8.7	294	91.3	1.50
Yearlings[1]	55	21.9	20	35.7	12	21.4	—	—	23	42.9	44	57.1	0.78
Unclassified	37	—	19	51.4	16	43.2	—	—	2	5.4	51	94.6	1.38
Grand Total and Average	288	100.0	106	36.8	137	47.6	3	1.0	42	14.6	389	85.4	1.35

[1] Yearling data were weighted so as to give a normal figure based on deaths resulting from all causes except malnutrition.

malnutrition (Table 2), and undetermined causes (Table 3). The question arose in the minds of the writers as to whether does which had died from malnutrition could safely be used in a study of this kind. It could be logically reasoned that the weaker does would be the ones most likely to succumb from malnutrition and they would include a high proportion of diseased animals as well as those in the yearling and old age classes. This supposition was found to be at least partly true since it was found that yearlings comprised 30.9 per cent of all does included in Table 2 (those which died of malnutrition) as against 21.9 per cent in Table 1 (does which died from causes other than malnutrition). There is reason to believe that the Table 1 value is fairly representative of the live females in herds from which the samples were taken. This is supported by the fact that of 620 does examined at checking stations in Utah and Nevada by the writers, 25.5 per cent were yearlings If the data are accepted as being representative, there was a disproportionately heavier loss of yearlings because of malnutrition than occurred with the older deer as revealed in Table 2. A further examination of Tables 1 and 2 reveals a significant difference in the fetal rates recorded for yearlings. In Table 1 there was a rate of 0.78 fetus per yearling doe as contrasted to only 0.39 in Table 2. This difference gave a significant chi-square value at the 5 per cent level. It may be further noted that whereas 57.1 per cent of the yearlings included in Table 1 were pregnant the corresponding percentage in Table 2 was 37.5. It appears from Table 1 that long yearling does as a class are not all sexually mature since only 57.1 per cent were found to be pregnant as contrasted to 92.0 per cent for the three older-aged classes. Consequently, in the yearling doe class where all the animals are not sexually or physically matured, one could expect that those which succumb from starvation would be the ones which are weakest and these animals in turn are probably those least likely to breed and produce young.

Further analysis of Table 1 (does dying from causes other than malnutrition) reveals that 2-year olds, prime, and old does treated collectively had a fetal rate of 1.52 per doe with 92.0 per cent being pregnant. The fetal rate was 1.50 per doe and the pregnancy rate 91.6 per cent for the females in the same age classes in Table 2 (does which died of malnutrition). The difference noted in the fetal rate was not significant as revealed by the chi-square test nor were the differences between individual age classes (2-year, prime, and old) for the two tables significant. It therefore appears that for does sexually and physically mature we can safely use pregnancy records for those which have died from malnutrition or other causes without fear of a significant error being introduced. However, in combining all of the pregnancy information it seems desirable to reject all data for yearling does which died from malnutrition. We have therefore combined in Table 4 all of the pregnancy records into what is considered to be a representative sample for herds with which we have worked. We have consequently expanded the yearling doe data from Table 1 so that it represents the same percentage of the sample in Table 4.

The 620 legally killed does which

have been aged by the writers during the past three years were found to be represented by the following percentages: yearlings—25.5 per cent, 2-year olds—15.0 per cent, prime—40.3 per cent, and old—19.2 per cent. These does were aged during the same period and from the same general areas where most of the pregnancy data have been obtained and are believed to reflect the composition of the doe herds. The percentages differ somewhat from those of the does examined for pregnancy as listed in Table 4. However, when the combined pregnancy data of Table 4 were weighted according to the age composition of the 620 does, a corrected rate of 1.34 fetuses per doe was obtained as compared to the 1.35 derived in the table. This difference is so small that no revision of Table 4 is deemed necessary. However, it should be emphasized that the age composition of does in Table 4 probably deviates somewhat from the actual composition of does in the live herds. The writers wish to make it clear that errors may have been made in segregating does in the prime and old age classes for only one skull of known age was available in the old age class. However, the same criteria for judging the age of does examined for pregnancy and those legally killed were used so that the results should be comparable.

From Table 4 it can be noted that 85.4 per cent of the does were pregnant. A listing of these data with the findings of other investigators in Utah and other states is presented in Table 5. The table shows that a total of 396 does has been examined in Utah and that 85 per cent of them were pregnant. This is lower than was found in California and Washington but is considerably higher than the findings in Colorado. In considering the California results it should be pointed out that only one yearling doe was present in their sample; thus the lower yearling pregnancy rate had little influence on the California data. A similar sized sample from the present Utah study would have included over seven yearling does. When the yearlings were excluded from the Utah data in Table 4, the rate of pregnancy increased to 91.3 per cent; however, when yearlings were excluded from the California data they had 100.0 per cent pregnancy. Recent correspondence with Randal McCain and William Dasman who have been studying the Interstate Herd reveals that mature does were selected in the California study so that the yearling does are not proportionately represented in the sample. In New York, Morton and Cheatum (1946) found that 87.2 per cent of 242 adult white-tailed does were pregnant. A comparison with similar Utah data in Table 4 reveals only a 1.8 per cent higher pregnancy for the New York sample.

GESTATION PERIOD

During the course of this study it has not been possible to secure data on the gestation period of the mule deer. A perusal of the literature reveals some variation in the periods given. Only two instances are known where actual gestation records are presented and they are as follows:

Authority	No. of Does	Range in Days	Average No. of Days
Nichol (1938)	9	193–205	199
Dixon (1934)	4	205–209	207
Total and Average	13	193–209	202

There was considerable variation in the gestation period of the individual does. These periods ranged from 193 to 209 days, a spread of 16 days. The average length of the gestation period was found to be 202 days which is a few days shorter than the commonly accepted 210 day period.

EMBRYO STUDY

Number of Young per Doe.—The pregnancy data are presented in Table 4. From this table it can be noted that the number of embryos per doe varies with the age class of the doe, the prime does being the most productive and yearlings the least. For ease of comparison, these data have been listed with those of other investigators in Table 5. From the table it can be noted that the present findings fall between the results of the other Utah workers. However, it is very close to the average of the entire Utah data of 1.36 embryos per doe. The California data are much higher than those of the present study. However, as previously explained the California sample did not contain a normal complement of yearling animals and for that reason should be greater. The Washington results are also greater than those from Utah while the Colorado findings are considerably less. The average for all the available data of 1.40 embryos per doe is only slightly above the 1.36 Utah average.

When one considers the data presented on the breeding potential of the mule deer it is readily apparent that there is considerable variation in the results. One can only surmise as to the reasons for these differences. However, in New York, Morton and Cheatum (1946) demonstrated that the breeding potential for the white-tailed deer varied between the northern and southern parts of the deer range in the State. They attributed this difference largely to the variation in the essential nutrients available to the deer. This could also account for at least part of the difference found in the mule deer records. As has been shown, a difference in the age classes of the does in the samples, as a result of malnutrition or other factors, could also account for a certain

TABLE 5.—SUMMARY OF MULE DEER PREGNANCY DATA INCLUDING ALL AGES EXCEPT FEMALES LESS THAN ONE YEAR OLD

Authority	State	Embryos									Does		
		Singles		Twins		Triplets		Barren		Total Number	Number	Per Cent Pregnant	No. Embryos Each
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent				
Doman and Rasmussen (1943)[1]	Utah	14	23.7	37	62.7	—	—	8	13.6	88	59	86	1.49
Fagergren[2]	Utah	13	26.5	25	51.0	—	—	11	22.5	63	49	78	1.29
Present Study, Table 4	Utah	106	36.8	137	47.6	3	1.0	42	14.6	389	288	85	1.35
Total and Average	Utah	133	33.6	199	50.2	3	0.8	61	15.4	540	396	85	1.36
Chattin (1948)	California and Oregon	14	28.6	32	65.3	2	4.1	1	2.0	84	49	98	1.71
Hunter and Spencer[3]	Colorado	8	17.8	22	48.9	—	—	15	33.3	52	45	67	1.16
Lauckhart (1948)	Washington	27	34.2	46	58.2	—	—	6	7.6	119	79	92	1.51
Grand Total and Weighted Average	—	182	32.0	299	52.5	5	0.9	83	14.6	795	569	85	1.40

[1] As reported by Robinette and Olsen (1944).
[2] Memorandum for Superintendent, Zion National Park dated August 3, 1945 from Fred Fagergren, Chief Ranger.
[3] Correspondence dated February 21, 1949 from Gilbert N. Hunter, Colorado Game Manager, relative to investigations made with Henry Spencer.

amount of variation. Larger samples would also probably give a better cross-section of the herds and thus help to eliminate a wide divergence of the data.

Relationship of Single, Twin, and Triplet Embryos.—During this study data were kept on the number of single, twin, and triplet embryos, and of barren animals by the age-class of the mother. An examination of Table 4 reveals that the yearling does had about one third more singles, than twins. The relatively large number of twins carried by the yearling does was noteworthy. It is commonly thought that at the first fawning (this would include many yearling does) the young are primarily singles. On the other hand, Dixon (1934), in writing of the California mule deer, gives data showing that the first young of a 2-year-old doe were twins. Rampont (1926) reported a short, 2-year-old black-tailed doe giving birth to twins at her first fawning in California. In New York, Morton and Cheatum (1946) found that 2 of 38 pregnant white-tailed fawns had twin embryos.

Table 4 also reveals a marked increase in the number of pregnant 2-year-olds over yearlings. Among the 2-year-olds the number of twins outnumbered the singles and only a small percentage of the does did not have embryos. The prime group also had a greater number of twins and in addition had a few sets of triplets. It is interesting to note that only the prime aged does had triplets. There was a slight decrease in the productivity of the old aged group of deer; single and twin embryos were found in nearly the same proportion.

A consideration of the combined data for the entire sample is of interest. The data suggest that at birth one could expect approximately a quarter more twins than singles and only a very small number of triplet fawns in a Utah deer herd.

For comparison, these data are presented in Table 5 with that of other investigators from Utah and other states. The present study reveals a higher percentage of single embryos and a lower percentage of twins than the other Utah data. However, it compares favorably with the combined Utah sample. The entire Utah sample has a higher percentage of single embryos than that of California-Oregon and of Colorado but is lower than was found in Washington. The percentage of twins was lower in the Utah data than that in California-Oregon and Washington, but was greater than that in Colorado. Besides Utah, triplets were reported only from the California-Oregon study where a higher percentage was found. Colorado had the greatest number of barren does followed by Utah, Washington, and California-Oregon in that order. A comparison of the combined Utah data with that of all the states listed reveals a very close correlation.

Sex Ratios.—From Table 6 it can be noted that a total of 250 sets of embryos was recorded. Of this group sex data were secured from 198 sets of embryos comprising a total of 307 individuals. Included were 171 males and 136 females giving a sex ratio of 126:100. A ratio of 117:100 was found to prevail in California by Chattin (1948).

Resorption of Embryos.—Resorption of embryos is generally accepted as a factor to be considered in studying the

reproductive capacity of a species. During this study the writers personally examined 203 pregnant does bearing a total of 318 embryos. Of these embryos, 3 (0.9%) were evidently being resorbed or were malformations. One was a single in which body tissues were obviously degenerating. The other two were each from a set of twins. One had a well-developed head with the body poorly developed and apparently retrogressing, the other instance was an embryo much smaller than its mate with its body degenerated to the point of being more of the consistency of a gelatinous material. Thus, a certain amount of resorption of embryos occurs among the mule deer; however, the incidence found in this study (0.9%) appears to be insignificant.

TABLE 6.—EMBRYO SEX RATIOS

Occurrence of Embryos	Number of Sets	Total Number			Sex Ratio Male:Female
		Male	Female	Unclassified	
Singles	116	53	38	25	139:100
Male	53	53			
Female	38		38		
Unclassified	25			25	
Twins	131	114	96	52	119:100
2 males	33	66			
Male-female	48	48	48		
2 females	24		48		
Unclassified	26			52	
Triplets	3	4	2	3	200:100
1 male-2 females	1	1	2		
3 males	1	3			
Unclassified	1			3	
Total or Average	250	171	136	80	126:100

Diseased Uteri.—The writers examined a total of 296 does for pregnancy. Of this group 2 (0.7%) displayed evidence by gross examination of being diseased. Both does were classed as old—one had about a quart of pus in her uterus, and the other had a ball of congealed pus as big as a clenched fist in hers. The actual cause of these disturbances was not determined and these observations are presented only as a matter of record.

FAWNING PERIOD

Two hundred and thirty-two fawns have been tagged during the last few years in Utah by the authors or by cooperators. Of this group, the age was estimated for 137 individuals the average being four days each. The remaining 95 fawns were tagged mostly by cooperators and no estimate of age was made. However, fawns become very active at an early date and few are captured after reaching 10 days of age. It was therefore considered permissible to allot to each the average age of four days since at the most their ages would logically vary only a few days. Thus a larger sample was made available for compilation in Figure 2.

It should be emphasized that these data do not represent a true sample. The greatest amount of effort was ex-

pended during the fawning peak by the authors and thereafter most of the work was done by several cooperators to whom tags had been distributed. However, it does accurately portray the fawning peak and probably gives the approximate extent of the fawning period.

From Figure 2 it can be seen that the fawning period started June 5, rapidly ascended to a peak by June 11, maintained a relatively high level until June 20, and fell gradually until the end of the period on August 19.

SUMMARY

1. The breeding season of the Rocky Mountain mule deer in Utah was determined by direct observation of copulation, by aging embryos and plotting the conception dates, and by using the ages of tagged fawns and figuring back to the date of conception. These methods revealed a breeding season starting the last few days of October, rising to a peak during the period November 20 to December 2, and declining gradually until the latter part of January.

2. Some mule deer males probably reach sexual maturity their first fall; however, their value as breeders must be slight. Yearling bucks display an interest in the does but are subjugated by the older males; they may play a more important role during the latter part of the rut when the older males are worn down from breeding activity and have started to lose interest in the does. Bucks above two years of age are keenly interested in the does and the extent of their mating appears to be dependent on their physical ability to claim does and fend off competitors.

3. The data suggest that a few female fawns may breed during their first fall or early winter of life. Pregnancy checks revealed 57.1 per cent of the yearlings, 94.4 per cent of the 2-year-olds, 92.4 per cent of the prime does, and 88.2 per cent of the old-aged group to be pregnant. For the entire sample, including all age classes except fawns, 85.4 per cent were pregnant.

4. Data on known gestation periods in the literature suggest one ranging from 193 to 209 days and averaging 202 days.

5. The number of embryos per doe varied by the age class of the does. Yearlings averaged 0.78 embryos, 2-year olds 1.47, prime does 1.63, and the old does 1.34.

6. Yearling does bore 35.7 per cent single embryos, 21.4 per cent twins, and 42.9 per cent were barren. The large number of twins is noteworthy since it is commonly believed that few twins are dropped at the first fawning. The 2-year old does had 41.7 per cent single embryos, 52.8 per cent twins, and 5.5 per cent were barren. Twenty-five per cent of the prime group had single embryos, 64.1 per cent had twins, 3.3 per cent triplets, and 7.6 per cent were barren. The old-aged deer had 42.6 per cent single embryos 45.6 per cent twins, and 11.8 per cent were barren. The combined data for the entire sample were 36.8 per cent single embryos, 47.6 per cent twins, 1.0 per cent triplets, and 14.6 per cent were barren.

7. Sex data were secured on 307 embryos. Of this group 171 were males and 136 were females giving a sex ratio of 126:100.

8. A total of 232 newly born fawns have been tagged in Utah in recent years. These revealed a fawning period starting June 5, rapidly ascending to a peak by June 11, maintaining a relatively high level until June 20, then falling gradually until the end of the period on August 19.

LITERATURE CITED

CHATTIN, J. E. 1948. Breeding season and productivity of the Interstate Deer Herd. Calif. Fish and Game, **34**(1): 25–31.

CHEATUM, E. L. and GLENN H. MORTON. 1946. Breeding seasons of white-tailed deer in New York. Jour. Wildl. Mgt., **10**(3): 249–263.

DIXON, JOSEPH S. 1934. A study of the life history and food habits of the mule deer in California. Calif. Fish and Game, **20** (3–4).

DOMAN, E. and D. I. RASMUSSEN. 1943. Life history studies of the Rocky Mountain mule deer in Utah. Ms.

LAUCKHART, J. BURTON. 1948. Black-tailed deer in Western Washington. Proc. 28th An. Conf. West Assoc. St. Fish and Game Com., 153–161.

MORTON, GLENN H. and E. L. CHEATUM. 1946. Regional differences in breeding potential of whitetailed deer in New York. Jour. Wildl. Mgt., **10**(3): 242–248.

NICHOL, A. A. 1938. Experimental feeding of deer. Univ. of Ariz. Coll. of Agric. Tech. Bul., 75.

RAMPONT, R. O. 1926. Black-tailed deer successfully reared. Calif. Fish and Game, **12**(1): 35–37.

RASMUSSEN, D. I. 1939. Mule deer range and population studies in Utah. N. Amer. Wildl. Conf., Trans., **4**: 236–243.

ROBINETTE, W. LESLIE and ORANGE A. OLSEN. 1944. Studies of the productivity of mule deer in Central Utah. N. Amer. Wildl. Conf., Trans., **9**: 156–161.

SHANTZ, H. L. 1943. Sexual maturity of deer. Hearings before the Select Committee on Conservation of Wildlife Resources, Seventy-eighth Congress, p. 288.

WINTERS, LAURENCE M. and GEORGE FEUFFEL. 1936. Studies on the physiology of reproduction in the sheep. IV. Fetal development. Univ. Minn. Agric. Exp. Sta. Tech. Bul., 118.

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OBITUARY

JOHN HAMMOND LEWIS

1913–1949

John Hammond Lewis, assistant professor of biological sciences at Humboldt State College, Arcata, California met his death in an auto accident on September 24, 1949. Widely known and well liked by all his associates, John Lewis had achieved considerable prominence in the West as an educator in the field of wildlife conservation and management. His strong personality and deep-in-the-heart interest in wildlife was infectious to those he met.

John Lewis was born July 9, 1913, in Fernley, Nevada. He obtained his early schooling in Reno, and attended the University of Nevada for one year before entering the employ of the Nevada State Highway Department, in whose service he remained for nearly five years. An avid naturalist, John Lewis enrolled in Fish and Game management at Oregon State College. Upon graduation in 1942, he accepted a position as rodent control specialist for the U. S. Fish and Wildlife Service, stationed at Eagle Point, Oregon. After six months at this work, he received an appointment as Junior Refuge Manager at Malheur Wildlife Refuge and remained there until entering the Navy in July, 1944. During the war he spent considerable time overseas in charge of rodent control work on Guam. In 1946 he was separated from the service and returned to Oregon State for additional graduate study. He received his M.S. in 1947. While in College he was active in Alpha Zeta (agriculture honorary), and a member of the social fraternity, Sigma Alpha Epsilon.

John Lewis then came to Humboldt State College and was placed in charge of the Wildlife Management courses. Under his direction the department mushroomed from a bare handful of students to over 100 in three years. He was especially proud of his "wildlifers" and maintained a high esprit de corps among the students.

An enthusiastic herald of the conservation gospel, he cheerfully gave his time and energy to numerous educational radio programs and speeches before the various community service organizations. He was instrumental in generating local interest to develop Big Lagoon, Stone Lagoon, and the South Spit of Humboldt Bay as public recreation sites.

He is survived by his wife, Mrs. Jess Lewis and children, Jill, James, Jerry, and Juduth, all of Arcata; his mother, Mrs. Helen Joslin of Reno; and his sister, Mrs. David Penn of New York.—FRED A. GLOVER.

PUBLICATION NOTICES

Trapping Methods for Bird Ringers. By A. D. Hollom. British Trust for Ornithology Field Guide Number One. The Potter Press, 29, St. Giles, Oxford, 40 pp. 1950. 2s./6d.

Active bird-banders will be interested in studying the traps and methods which have proved successful in the British Isles and on the Continent.

Bird-Watching. The Fifteenth Annual Report of the British Trust for Ornithology. The Potter Press, 29, St. Giles, Oxford. 48 pp. illus. 1949. 1s./6d.

The British Trust for Ornithology administers many types of ornithological research including the national bird banding program. Among the many projects which will interest Journal readers is the nationwide census of the great crested grebe, estimated to be 90 to 95 per cent complete. Those interested in securing publications of the Trust may address the Secretary, 91, Banbury Road, Oxford, England.

North American Census of Small Mammals. Edited by John B. Calhoun. Release No. 3, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine. 1950. 90 pp.

This report, reproduced by offset, presents the results of trapping on 154 plus trap lines well distributed throughout the United States and Canada.

Rocky Mountain Bighorn Sheep of Montana. By Faye M. Couey. Montana Fish and Game Commission, Bulletin No. 2. 90 pp. 1950.

This processed publication presents a wealth of data on bighorn sheep in Montana. History, present distribution, habits, parasites and diseases, predator relationships, general ecology, and management are included, largely from original studies of the project.

Suomen Riista. Published by the Finnish Foundation for Game Preservation, Game Research Institute, Helsinki, P. Rautatiek. 13, Finland.

This annual volume, of which No. 4 for 1949 has been received, contains each year a number of papers of great interest to American readers. The current number includes four papers, each in Finnish or Swedish (the second national language of Finland), but each with an English summary. Muskrats in Finland, damage to forests by moose, whitetailed deer in Finland, and a national game survey are the subjects of the 1949 papers.

Oikos. Acta Oecologica Scandinavica. Volume 1, 1949. Subscription is 40 Danish Crowns per annum, payable to Ejnar Munksgaard, Publishers, Copenhagen, Denmark, not to the editors.

"*Oikos* is an ecological journal representing ecologists in Denmark, Finland, Iceland, Norway, and Sweden.

"It is issued twice a year, with a total content of about 320 pages. It contains original papers by Scandinavian ecologists on terrestrial, marine, and limnic ecology, botanical as well as zoological. Papers on other sciences, such as pedology and climatology, with a clear ecological aspect will also be printed. Foreigners are invited to write on Scandinavian ecology.

"Summaries of comprehensive ecological works, originally published in Scandinavian languages, will also appear in Oikos. The journal gives critical reviews of important ecological papers published elsewhere. Thus it presents Scandinavian literature to foreign scientists and foreign literature to Scandinavian ecologists."

This newcomer among ecological periodicals has a promising beginning. The several Scandinavian governments have lent financial support to initiate the journal, which is edited by Dr. Erik Dahl, Zoological Institution of the University, Lund, Sweden, together with branch editors in each country. A majority of the papers are published in English, others in German or French.

Among the papers in Volume 1 which will interest the student of vertebrates are, "Some Remarks on the short-term fluctuations in the numbers of northern birds and mammals," by Pontus Palmgren, which is a criticism of Siivonen's 1948 paper on the same subject; "Competition and habitat selection in birds," by Gunnar Svardson; and several reviews.

It is evident that the libraries at the many American institutions where ecology is studied will find Oikos an essential addition to their shelves.

Wildlife Management Bulletin. Department of Resources and Development, Development Services Branch, Canadian Wildlife Service, Ottawa, Ontario, Canada.

The Canadian Wildlife Service has initiated three series of processed publications under the above title, No. 1 for mammals, No. 2 for birds, and No. 3 for fishes. The first issue in each series is as follows:

Series 1, No. 1, April 1950. The Mammals of Waterton Lakes National Park, by A. W. F. Banfield.

Series 2, No. 1, April 1950. A Study of Bird Populations in the Apple Orchards of the Annapolis Valley, Nova Scotia, with Particular Reference to the Effects of Orchard Sprays Upon Them, by John P. Kelsall.

Series 3, No. 1, May 1950. Prince Albert National Park Creel Census Analysis Season 1948, by Victor E. F. Solman.

Report on Conservation of Renewable Resources in Latin America. Compiled by Annette L. Flugger and Rosa Dora S. Keatley of the Division of Agriculture

and Conservation. Department of Economic and Social Affairs, Pan American Union, Washington, D.C. February, 1950. Mimeographed, 52 pp.

Survey of the Colorado Fur Resource. By Lee E. Yeager and Richard N. Denney and Harold C. Hammit. Final Report, Federal Aid Project 47-R, Colorado Game and Fish Department, Denver, Colorado, Current Report 25, September, 1949. 64 pp.

Income from the sale of raw furs in Colorado is estimated at $500,000 to $600,000 annually. The survey results were based upon personal interviews with 20 per cent of the licensed trappers of the state. Each species is discussed under the heads popularity, damage and control, populations, habitats, trappers and trapping.

Conservation and Nevada. A textbook for use in Nevada Schools. Prepared by a committee consisting of S. S. Wheeler, Director, Nevada Fish and Game Commission, and others. Issued by Nevada State Department of Public Instruction, Carson City, Nevada. 1949. 131 pp.

BRIEFER ARTICLES

USE OF THE HELICOPTER IN WILDLIFE WORK

A helicopter census of pronghorn antelope was made on the Wichita Mountains Wildlife Refuge in southwestern Oklahoma on July 6, 1949 through cooperation of personnel at Fort Sill. James K. Knox, civilian instructor in the Air Training Department piloted the R13B (or 47–D) Bell helicopter. The pronghorn population consisted of 10 bucks, 17 does, and 22 fawns. Only 5 of the males were seen from the helicopter; 5 others were established from the ground. At this season some of the bucks were scattered in mountainous, oak-savanna areas where they were difficult to observe, especially when they did not move about. It was interesting to note that the isolated bucks were not frightened appreciably by the helicopter, although pronghorns in herds ran at top speed to escape the noisy aircraft. The herds attempted to follow established escape patterns even over rough, rocky ground or up boulder-strewn slopes of about 45 degrees. One herd of 18 resorted to oak-savanna cover for protection after running about 1.5 miles in open grassland. Observations from the ground indicated a population of 9 bucks, 17 does, and 19 fawns, but with no assurance that some of the does and fawns had not been counted more than once. From the air one yearling buck was seen; no yearling males were seen from the ground.

The Bell Aircraft model 47-D2 helicopter is probably the most suitable for wildlife work, since its higher horsepower (205 hp. compared with 178 hp for the 47-D) permits greater maneuverability in mountainous terrain where downdrafts, air pockets, and high altitude handicap flying. It also has the advantages of being 3-place, rather than 2-place, and having a greater gasoline capacity. Purchase price of the Bell helicopter is $27,000.00; that of the Sikorsky $50,000.00. Operating costs given by Bell Aircraft are $36.00 per hour when operating at a minimum of 300 hours per year, or less when operating more hours. This cost includes purchase of the machine, insurance, pilot's salary, maintenance, and operating costs. Pilot training courses are given at factories and by several flying services in various parts of the country at a cost of approximately $1,500.00. Since helicopters may be hired for about $50.00 per hour, it is probably more economical at present for State game departments and other agencies to hire helicopters rather than purchase them unless they are used frequently and effectively.

The helicopter obviously has many advantages over the airplane for wildlife censusing in that it may be flown at any speed from 0 to about 90 mph and has much greater maneuverability. It may be safely flown near the ground or in canyons, providing the pilot is skilled in flying, takes advantage of winds, and avoids downdrafts. There are definite limitations imposed by timber and to some extent by downdrafts in

mountainous terrain. Only 25 elk (5 bulls, 13 cows, and 7 calves) were seen while on the 1-hour (0840–0940) flight during which pronghorns were counted, yet ground observations indicate that at least 143 elk used the area covered. Elk were not seen readily in oak woods where they retired after their early morning feeding period. Movements were conspicuous only when the helicopter approached directly over the elk. Counts made immediately after daybreak would give an index to the elk population but would probably be subject to considerable error. Only four whitetail deer were seen during the flight, indicating that dense foliage makes deer censusing impractical even from a helicopter.

Helicopters have been employed to facilitate wildlife work in other parts of the country. In the southeastern States they have been useful in convicting violators of waterfowl regulations. The State of Washington Department of Game found the helicopter the only instrument that could drive elk out of orchards in the Yakima area during the severe winter of 1948–1949. Helicopters have been used occasionally in Washington for patrolling streams, investigating timber resources, inventorying big game on Forest Service lands, and transporting sportsmen to high mountain lakes. Doubtlessly helicopters will be utilized in many States to aid in wildlife protection, censusing, mapping, photography, and many other phases of wildlife research and management. At the present time high costs limit their use; when they become more economical, helicopters will probably be one of the most useful instruments available for wildlife work.—HELMUT K. BUECHNER, *State College of Washington, Pullman, Wash.*

Accepted for Publication August 10, 1949.

THE OCCURRENCE OF BLOOD PARASITES OF GROUSE IN CENTRAL PENNSYLVANIA[1]

While engaged in a population study of the ruffed grouse (*Bonasa umbellus subsp.*) in central Pennsylvania, the writers obtained blood smears from thirty live-trapped wild grouse. These smears were made in the field and were later fixed with Wright's stain in the laboratory.

The thirty birds were taken in two localities, both study areas for the population study which was a project of The Pennsylvania Cooperative Wildlife Research Unit. This study was made under the supervision of Dr. Logan J. Bennett, former Leader of The Pennsylvania Cooperative Wildlife Research Unit, and Dr. P. F. English, Professor of Wildlife Management, The Pennsylvania State College. Dr. A. M. Fallis of the Ontario Research Foundation kindly examined some of the slides and identified the parasites which were present.

The first area, where six grouse were captured, was near Charter Oak in Huntingdon County, and the second area, where twenty-four grouse were captured was near Scotia in Centre County. There appeared to be a higher incidence of parasites in the blood of birds from the Huntingdon County area, which was about nine air miles distant from the Centre County area. The intervening terrain consisted of a forested ridge, Tussey Mountain, and agricultural land.

Examination of the smears from the Huntingdon County grouse showed that all six of them carried blood parasites, four of the six carried more than one species of parasite. Five of the six grouse carried *Leucocytozoon sp.*, four harbored *Haemoproteus sp.*, two carried *Microfilaria sp.* and a like number bore *Trypanosoma sp.* One bird harbored all four of the parasites named. The date of capture of these birds and the parasites found are listed in Table 1.

[1] Paper No. 53 from the Pennsylvania Cooperative Wildlife Research Unit. Fish and Wildlife Service (U. S. Department of the Interior), The Pennsylvania State College, the Pennsylvania Game Commission, and the Wildlife Management Institute cooperating.

Authorized for publication on June 14, 1949 as Paper No. 1523 in the journal series of the Pennsylvania Agricultural Experiment Station.

TABLE 1.—HUNTINGDON COUNTY GROUSE

Date Captured	*Blood Parasites*
9-26-46	H.
4-19-47	L.
4-23-47	L, H, T, M.
9-20-47	L, M.
9-24-47	L, H, T.
10- 2-47	L, H.

Fifteen of the twenty-four smears from the Centre County grouse showed no parasites. Three of these birds were retrapped six or more months later and smears made then showed no parasites. Of the nine infected birds only one carried more than one species of parasite, it harbored both *Leucocytozoon sp.* and *Haemoproteus sp.* In the nine infected birds *Haemoproteus sp.* occurred seven times and *Leucocytozoon sp.* occurred three times. The date of capture and the parasites found are listed in Table 2.

The cause of the apparent more frequent occurrence of blood parasites in grouse on the Huntingdon County area was not clear. There are numerous streams on the Huntingdon County area, and insects, especially flies, are abundant in the warmer seasons. The Centre County area lacks streams, and flies such as are found on the Huntingdon County area are uncommon. Mosquitoes are abundant on the Centre County area during warm periods when the many shallow sinks contain water. The presence of adequate insect carriers may be responsible for this difference in representation of blood parasites of grouse on the two areas.—GLEN L. BOWERS and WARD D. TANNER, *Pennsylvania State College, State College, Pa.*

TABLE 2.—CENTRE COUNTY GROUSE

Date Captured	*Parasites Found*	*Date Captured*	*Parasites Found*
9- 9-47	None	10-19-47	None
9-12-47	L., H.	4-18-48*	None
9-17-47	H.	10-22-47	H.
9-18-47	None	4-18-48	None
9-24-47	H.	4-20-48	L.
10- 5-47	H.	4-20-48	None
10- 7-47	None	4-21-48	L.
10- 7-47	None	4-22-48	None
10- 7-47	None	4-23-48	None
4-20-48*	None	5-14-48	None
10- 8-47	None	5-14-48	H.
10- 8-47	None	5-18-48	H.
5-15-48*	None	5-21-48	None
10-14-47	None		

* Recapture of grouse listed immediately above.

L *Leucocytozoon sp.*
H *Haemoproteus sp.*
M *Microfilaris sp.*
T *Trypanosoma sp.*

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A HIGH MORTALITY OF PEN-RAISED BOB-WHITE QUAIL

On April 28, 1942, the writer banded and released fifty pen-raised Bob-white Quail (*Colinus v. virginianus*) in northern Pulaski County, Kentucky. Prior to their release the birds had never set foot upon the ground, and showed little fear of man. One of the birds was caught by hand after three short flights, the longest of which was no greater than twenty-five yards.

A thorough survey of the area on May 7, 8, and 9, 1942, disclosed no live banded birds and 28 dead ones. Of the dead birds, fifteen had either been killed by predators or utilized as food by them after dying from other causes. The other thirteen birds showed no signs of predation, but were extremely emaciated. Subsequent surveys of the area revealed no banded birds.

That the area where the birds were released was suitable quail habitat is attested by the fact that a covey of birds inhabited the area when the releases were made. Apparently no unusual conditions existed among the pen-raised birds; they appeared no different from birds released in other areas. The incidence of predators was no higher than in other areas; no unusual climatic conditions existed between the time the birds were released and when they were found dead.—ROGER W. BARBOUR, *Dept. of Zoology, University of Kentucky, Lexington.*

Accepted for Publication October 13, 1949.

NOTES ON THE FOOD HABITS OF PEN-RAISED BOB-WHITE QUAIL

At six o'clock on the morning of March 3, 1942, the writer banded and released four pen-raised Bob-White Quail, (*Colinus v. virginianus*), near Science Hill, Pulaski County, Kentucky. These birds had no food of any sort on March 2, and prior to their release had not set foot upon the ground. Between five and five-thirty p.m., after some 11 hours of freedom, the birds were collected in order to determine what they had eaten. All were collected within fifty yards of the point of release.

The following tabulation shows the result of subsequent stomach analyses by the Fish and Wildlife Service:

Major Food Items

Food	*Per Cent*
Unidentified leaves	36.25
Smilax sp.	31.25
Rhus glabra	29.50
Rhus sp.	1.50
Chilopoda	1.50

Minor Food Items

Food	*Occurrence (No. of stomachs)*
Cercis canadensis	2
Chrysomelidae	1
Cornus florida	1
Morus sp.	1
Unidentified grassy material	1

Another bit of interesting information came to light near Anna, Warren County, Kentucky. In this instance the remains of a banded, pen-raised quail were found on May 29, 1941. The bird had been released on April 17, 1941, and had apparently been killed by a predator some three or four days before the remains were found. Examination revealed the crop to be intact, and analysis of its contents by the Fish and Wildlife Service showed the following materials:

	Food Item	*cc.*	*%*
3	*Cornus florida*	0.2	4
15	Coleoptera, Chrysomelidae: *Zygogramma sututalis*	0.5	10
83	Coleoptera, Curculionidae: *Tanymecus confertus*	2.8	59
14	Lepidoptera, Larvae	1.0	21
10	Hymenoptera, Formicidae: *Formica fusca* var. *subserica*	0.1	2
85	Hymenoptera, Formicidae: *Lasius niger*	0.2	4

In addition the bird had taken an exceptionally wide variety of food as indicated by the fact that one plant and 27 species of animals were identified, occurring only in trace amounts. These included *Rhus* as the only plant, and the following animals: 1 Orthopteran; 1 Hemipteran; 15 species of Coleoptera representing the families Carabidae, Elateridae, Scarabeidae, Chrysomelidae, Cantharidae, and Curculionidae; 3 Dipterans of the family Bibionidae; 5 Hymenopterans of the family Formicidae; 1 Araneida; and 1 Chilopoda.—ROGER W. BARBOUR, *Oglebay Institute, Wheeling, West Va. Oct. 11, 1949.*

KILL ANALYSIS FOR THE LESSER PRAIRIE CHICKEN IN NEW MEXICO, 1949

INTRODUCTION

A short hunting season of the lesser prairie chicken (*Tympanuchus pallidicinctus* Ridgway) was held in an area of some 1,800 sections (sq. mi.) of land in southeastern New Mexico, beginning at noon on the 26th and closing at 4:30 p.m. on the 28th of November, 1949. This was the second time that a hunting season of these birds had been allowed since 1934. In 1948 a very good season was held at about the same time and under the same restrictions and a large number of birds taken. In the early 1930's a combination of drought and resultant overgrazing of the prairie chicken range had driven the birds in New Mexico to the brink of extermination.

The birds began to increase, however, following a period of favorable breeding weather and widespread habitat improvement under the Pittman-Robertson Federal Aid program. More adequate law enforcement, effective predator control, and landholder cooperation were all useful in encouraging the increase to an extent that a restricted hunt was permitted in 1948. While the kill was quite heavy that season an extensive survey in the fall of 1949 of the prairie chicken range showed an adequate number again to justify a second season.

Plans were made by the New Mexico Department of Game and Fish to get as much information on the lesser prairie chicken as possible by a careful check of the hunter's bag. The main effort was concentrated on aging, sexing and weighing each bird checked.

METHODS

By means of field checks during the day and check stations set up in the late afternoon at the two most important crossroads leading out of the area, it was possible to examine 962 birds, of which number 923 were sexed, 903 aged, and 700 were weighed. Field checks during the day did not include weighing in most cases since it seriously interfered with the hunters' pursuit of the birds. Most weight, sex and age records were taken at the check stations just before the close of the day's hunting, and from then on until all hunters had checked through the road block. Equipment used at the stations consisted of poultry scales, powerful spotlights and record books. Two technicians were required to operate each station in addition to the law enforcement personnel. The methods used in classifying the birds was a combination of information obtained from Bent (1932), Dwight (1900), and Ammann (1944). Very little information exists on the plumages, and age and sex differences of the lesser prairie chicken. Ammann's work was done on the greater prairie chicken (*Tympanuchus cupido americanus* Reichenbach), but it was found that his method of aging by primary feather wear was just as applicable to the lesser as to the greater prairie chicken. Sexing the birds was quite easy, but age determination was much more difficult in view of the minor differences between adult and immature birds. The difference in tail coloration of males and females, both young and adult birds, is quite evident. The dark brown tail feathers of the male are banded with buff at the tip, while those of the female are light brown and barred in varying degrees with lighter buff throughout the length of the tail feathers. This difference applies to both immature and adult birds. Individual variation was in some cases extreme, and without internal examination, such birds could not be positively aged on a field check. It is believed, however, that most age determinations are correct.

DISCUSSION

The first afternoon of the season produced the best hunting. The favorable weather on the first day probably contributed to the hunter success. High winds and cold interfered seriously with the last two days of the hunt. Based on a spot check of 167 hunters in 47 cars, the average hunter success was 1.96 birds per hunter, an excellent average. The prairie chickens were widely scattered in small bunches over the range lands adjacent to the cultivated fields of sorghum and corn, the principal crops of this dry land farming region.

The range lands which enclose the fields are principally low sand hills with a mixed vegetation of shin-oak (*Quercus havardi*), sand hill bluestem (*Andropogon* spp.), sand sage (*Artemesia* spp.), sunflower (*Helianthus* spp.), mesquite (*Prosopis glandulosa*), wild plum (*Prunus* spp.), yucca (*Yucca glauca*), dropseed (*Sporobolus* spp.), grama grass, mainly black and blue with some sideoats grama (*Bouteloua eriopoda, B. gracilis* and *B. curtipendula*). These plants are interspersed with numerous weeds such as dayflower (*Commelina* spp.), loco (*Astragulus* spp.), milkweed (*Asclepias* spp.), russian thistle (*Salsola pestifer*), and snakeweed (*Gutierrezia sarothrae*). Heavy cattle grazing is usual in this area and range deterioration is often conspicuous.

The prairie chickens of the area habitually feed in the fields during the fall and winter. They come into the fields at sunup and again just before sundown. They usually fly into the feed ground from their daytime resting places in the shinnery covered sand hills bordering the fields. If the distances are short they may walk, but flights of a mile and more are not unusual.

The proportion of young birds bagged compared with the adults taken was somewhat surprising. Of 923 birds checked 491 were immature, 432 adult. It had been expected that a greater proportion of young birds would be taken than was found to be the case. There seemed to be no evidence of any difference in ease of taking young and old birds, or of male and female.

The 491 immature birds included 231 females and 260 males. The 432 adults included 231 females and 201 males. The findings that an equal percentage of young and old females was taken, as compared with the imbalance between immature and adult males, is not readily explainable.

The flocking together of the same age and sex groups of prairie chickens was indicated by frequently finding that the bag of a group of hunters, who had hunted together, was all composed of birds of the same age or sex, more frequently of the same sex than of the same age. From information obtained from local ranchers and farmers and Game Department personnel stationed in the area, the flocking of birds of the same age and sex in the fall is not uncommon.

A total of 700 birds were weighed, but no significant differences were found between the weight of adults (which averaged 1.57 pounds), and immatures (which averaged 1.58 pounds).

ACKNOWLEDGEMENTS

The success of this work was due to the helpful cooperation of the following personnel of the New Mexico Department of Game and Fish: Mr. Elliott S. Barker, State Warden; Mr. Paul Russell, Pittman-Robertson Coordinator; Mr. Jack Samson, Dir. of Information and Education; Mr. Marion Embrey, District Game Warden; and especially to Mr. James L. Cox, Head of the Upland Game Division; and to Mr. E. M. Lang and Mr. Howard Campbell, Wildlife Technicians, and Mr. S. Paul Gordon, Graduate Student in Wildlife Management, Oklahoma A. & M. College, Stillwater, Oklahoma.

LITERATURE CITED

AMMANN, GEORGE A. 1944. Determining Age of Pinnated and Sharp-tailed Grouses. Jour. Wildl. Mgt., *1944*(2): 170–171.

BENT, ARTHUR C. 1932. Life Histories of North American Gallinaceous Birds. Smithsonian Institution. Bull. 162.

DWIGHT, JONATHAN, JR., M.D. 1900 The Moult of the North American Tetraonidae (Quails, Partridges, and Grouse). The Auk, **XVII**(2): 143–166.—LEVON LEE, *Biologist, Department of Game & Fish, Santa Fe, New Mexico. Jan. 26, 1950.*

NOTE ON THE BEHAVIOR OF MARSH HAWKS TOWARD LESSER PRAIRIE CHICKENS

On the afternoon of Feb. 8, 1949, the writer, along with J. Stokley Ligon, James L. Cox, Levon Lee and R. E. Lebow, all of the N. M. Dept. of Game and Fish, witnessed the following interesting, and possibly significant, occurrence in the sandhill country of southeastern New Mexico, a few miles east of Milnesand. This is in the heart of the area in which the lesser prairie chicken (*Tympanuchus pallidicinctus*) has within the last few years staged such a remarkable comeback to a condition of abundance from a condition of near-extermination during the severe drought years of the middle 'thirties.

During an attempt to net-trap some of the birds for experimental purposes, we watched a certain location, much frequented by the prairie chickens, for about three hours. Flocks of various sizes were all around.

During almost the whole time that we had the chickens under observation one, and part of the time two, marsh hawks (*Circus hudsonius*) constantly patrolled a surrounding territory of perhaps one section, keeping always out of shotgun range of our parked cars from which we observed the proceedings. These hawks kept flushing flock after flock of the chickens. Each time, the hawk would rapidly follow the flying chickens for some distance, then repeat the procedure with the same or another flock. In this way, between them the two hawks kept the entire prairie chicken population of quite a sizeable area in a state of constant alarm and agitation, much to the annoyance of the would-be trappers.

Toward evening, numbers of the prairie chickens began feeding out into the field in which the trap was set. The marsh hawks now began to concentrate on the field, and drove quite a number of the birds back to cover. Suddenly, one of the hawks darted into a flock just flushing, striking one bird hard

enough to knock it completely to the ground from an elevation of six or eight feet and produce a small shower of feathers. Before the hawk could follow up its advantage, the downed chicken made a desperate recovery and flew off with the others.

Field observations such as this appear to indicate that we need more definite knowledge of the relation between marsh hawks and prairie chickens. The latter (of which we had some two or three hundred under observation on this occasion) certainly seemed greatly alarmed by the marsh hawks.—HOWARD CAMPBELL, *Dept. of Game and Fish, Albuquerque, N. M., Nov. 8, 1949.*

LEAF BEETLE VERSUS LOTUS

The American lotus, *Nelumbo pentapetala* (Walt.) Fern., sometimes called yonkapin, is one of the fastest growing plants on Reelfoot Lake, Tennessee. It is of practically no value for waterfowl and is objectionable because it crowds out desirable duck-food plants. Considerable expense and time is spent at Reelfoot and numerous other places in efforts to control this giant pad-leaf plant.

For years guides and commercial fishermen at Reelfoot have reported that white larvae on the lower submerged portion of the leaf petioles have destroyed large numbers of this plant. Also, it has been noted that the activity of these larvae usually declines in July. During the summer of 1949, however, the insect remained active through August, when lotus is most susceptible to control, and killed back much of the plant—especially along the more open margins of its growth.

Pulled leaf stalks of the infested plants revealed several round holes from some of which were protruding the posterior portion of the larvae. Judging by its dark caudal spines and the nature of the damage to the plant, the insect was easily recognized as a species of *Donacia*. Members of this genus of leaf beetles (Chrysomelidae) feed upon aquatic plants, particularly *Nuphar*, *Sagittaria* and *Sparganium*.

Adult beetles were extracted from the oval brownish pupal cases attached to the petioles. These were determined by H. S. Barber of the United States National Museum as *Donacia hypoleuca* Lac., which, according to records, was previously collected at Samburg and Walnut Log on Reelfoot Lake by W. L. McAtee in July, 1919. It has also been taken locally from New Jersey to the District of Columbia and from Michigan to Texas.

Inasmuch as this leaf beetle was so destructive to the lotus at Reelfoot Lake in 1949 and apparently makes some annual contribution in this respect, it is desirable that appraisals be made in various parts of the range of lotus to determine the extent of biological control by this and other species of *Donacia*.—JOHN H. STEENIS and ROBERT T. MITCHELL, *U. S. Fish and Wildlife Service, Patuxent Research Refuge, Laurel, Maryland. Dec. 14, 1949.*

FOOD REMAINS IN STOMACHS AND INTESTINES OF IOWA RED FOXES

An investigation of the Northern Plains Red Fox (*Vulpes regalis*) for the Iowa Cooperative Wildlife Research Unit involved the collection of carcasses throughout Iowa during 1938 to 1941 inclusive, 1947 and 1948. Study of these carcasses included identification of food remains in 215 stomachs and 257 intestinal tracts, largely from foxes taken in winter. The findings reflect the general dietary patterns revealed by laboratory analysis of fecal passages and field observations on closely observed areas (Scott, Ecol. Monog., 13: 427–479, 1943; Iowa Agr. Exp. Sta. Res. Bul. 353, 1947).

The food identifications were grouped by month for convenient analysis. Some months were represented by too few samples to justify representation in a table. The occurrences of food remains in these samples are reported upon as follows: April (3 stomachs), *Peromyscus* sp. 1, *Synaptomys cooperi* 1, *Microtus* sp. 1 and *Sylvilagus floridanus* 1; May (2 stomachs), *Citellus tridecemlineatus* 1, *Peromyscus* sp. 2, *Microtus* sp. 1, and *Zen-*

TABLE 1.—OCCURRENCES OF FOOD REMAINS IN STOMACHS AND INTESTINES OF IOWA RED FOXES

	Stomachs			Intestines		
	December	January	February	December	January	February
Number examined	46	102	54	41	123	87
MAMMALS	67.2 (45)*	60.5 (98)	67.1 (51)	66.7 (38)	66.7 (120)	70.0 (84)
Undetermined		2.5 (4)	2.5 (2)		1.7 (3)	1.7 (2)
Determined		58.0 (94)	64.6 (50)		65.0 (118)	68.3 (83)
MARSUPIALS	1.1 (1)					
Didelphis virginiana	1.1 (1)					
INSECTIVORES		1.3 (3)	1.9 (2)	2.8 (2)	0.8 (2)	2.5 (4)
Scalopus aquaticus		0.4 (1)				0.6 (1)
Sorex cinereus			1.0 (1)	1.4 (1)		
Blarina brevicauda		0.9 (2)	1.0 (1)	1.4 (1)	0.8 (2)	1.9 (3)
CARNIVORES	1.1 (1)	0.5 (1)				
Procyon lotor		0.5 (1)				
Mephitis mephitis	1.1 (1)					
RODENTS	22.8 (20)	27.9 (62)	32.8 (35)	20.9 (15)	33.1 (86)	35.1 (57)
Undetermined	3.4 (3)	9.5 (21)	11.8 (13)	4.2 (3)	7.7 (20)	10.3 (17)
Determined	19.4 (17)	18.4 (41)	21.0 (23)	16.7 (12)	25.4 (66)	24.8 (41)
Citellus tridecemlineatus	0.9 (1)					
Geomys bursarius		0.7 (2)	0.8 (1)		0.6 (2)	0.9 (2)
Reithrodontomys megalotis		0.4 (1)	1.5 (2)	4.5 (4)	3.6 (13)	2.2 (5)
Peromyscus spp.	6.5 (7)	9.2 (25)	10.5 (14)	1.1 (1)	9.2 (33)	9.3 (21)
Synaptomys cooperi					0.3 (1)	
Microtus spp.	11.1 (12)	7.4 (20)	8.3 (11)	8.9 (8)	10.9 (39)	12.4 (28)
Mus musculus		0.7 (2)		2.2 (2)	0.8 (3)	
Rattus norvegicus	0.9 (1)					
RABBITS	42.1 (37)	24.7 (55)	26.2 (28)	43.1 (31)	29.6 (77)	29.5 (48)
Sylvilagus floridanus	41.0 (36)	22.9 (51)	25.3 (27)	40.3 (29)	29.2 (76)	28.9 (47)
Lepus townsendii	1.1 (1)	1.8 (4)	0.9 (1)	2.8 (2)	0.4 (1)	0.6 (1)
HOOFED MAMMALS		3.5 (8)	3.7 (4)		1.5 (4)	1.2 (2)
Sus scrofa		3.5 (8)	3.7 (4)		1.5 (4)	1.2 (2)
BIRDS	25.4 (17)	30.9 (50)	27.6 (21)	26.3 (15)	27.2 (49)	25.8 (31)
Undetermined	9.0 (6)	16.7 (27)	11.3 (9)	17.5 (10)	18.3 (33)	15.0 (18)
Determined	16.4 (11)	14.2 (23)	16.3 (13)	8.8 (5)	8.9 (16)	10.8 (13)
Non-game	11.9 (8)	10.5 (16)	12.5 (10)	5.3 (3)	6.5 (11)	8.3 (10)
GALLIFORMES	11.9 (8)	9.1 (15)	11.4 (10)	3.5 (2)	4.3 (8)	7.5 (10)
Gallus gallus	11.9 (8)	9.1 (15)	11.4 (10)	3.5 (2)	4.3 (8)	7.5 (10)
PASSERIFORMES		1.2 (2)	1.1 (1)	1.8 (1)	2.2 (4)	0.8 (1)
Game	4.5 (3)	3.9 (6)	3.8 (3)	3.5 (2)	2.4 (4)	2.5 (3)
GALLIFORMES	4.5 (3)	3.9 (6)	3.8 (3)	3.5 (2)	2.4 (4)	2.5 (3)
Colinus virginianus	1.5 (1)					
Phasianus colchicus	3.0 (2)	3.9 (6)	3.8 (3)	3.5 (2)	2.4 (4)	2.5 (3)
INSECTS		0.6 (1)			1.1 (2)	0.8 (1)
PLANTS	7.5 (5)	8.0 (13)	5.3 (4)	7.0 (4)	5.0 (9)	3.3 (4)
GRAMINEAE-CYPERACEAE	7.5 (5)	6.8 (11)	4.0 (3)	7.0 (4)	3.9 (6)	0.8 (1)
Zea mays		0.6 (1)	1.3 (1)		0.6 (1)	2.5 (3)
Prunus americana					0.6 (1)	
Vitis sp.					0.6 (1)	
Physalis sp.		0.6 (1)				

* First figure is per cent of total occurrences; figure within parentheses is the number of occurrences.

aidura macroura 1; September (1 stomach), *Gallus gallus* 1; November (7 stomachs and 4 intestines), *Scalopus aquaticus* 1, *Procyon lotor* 1, *Peromyscus* sp. 1, *Microtus* sp. 2, *Sylvilagus floridanus* 9, and undetermined bird 1; March (1 stomach and 2 intestines), *Peromyscus* sp. 2, *Sylvilagus floridanus* 1, undetermined Passeriformes 2, and *Zea mays* 2.

Identifications of food remains from the digestive tracts of those foxes collected in December, January and February are presented in Table 1. The method of analysis is that previously described for food remains found in fecal passages (Scott, Ecol. Monog., 13, 427–429, 1947).

The proportions of occurrences of foods found in the stomachs are remarkably similar to those in the intestines (Table 1). This similarity in proportion was affected but little by analysis of food remains from the stomach and intestine of the same fox, for less than half of the total number of stomach and intestinal samples analyzed were from the same digestive tract. This suggests that there may be little reason for analyzing food samples from the stomach separately from those of the intestine when the method of analysis here employed is used.

Food habit studies in which food remains are identified in the digestive tracts of animals of known sex permits determination of food preferences by sex. A comparison of the

diet of the male and female foxes during the winter months revealed no apparent difference in this instance.

The exact time of death was known for 23 of the red foxes. Determination of the whereabouts of food remains in the digestive tracts indicated that there was some rhythm to their daily feeding habits. Food was found throughout the digestive tracts of five foxes known to have been shot between 11:00 a.m. and 1:00 p.m. Of nine foxes killed between 2:00 and 3:00 p.m. four proved to contain food throughout the digestive tract, and in the remaining five, food was found only in the intestines. Of nine foxes killed later in the day, between 3:00 and 4:00 p.m., only three contained food throughout the digestive tract; five contained food only in the intestines, and the digestive tract of one animal was empty.

Such understanding of red fox predation as may be realized from these findings extends little, if any, beyond the general dietary patterns evident in Table 1. Perhaps some importance may be attached to the single occurrence of bob-white (*Colinus virginianus*) remains in the 472 stomachs and intestines examined. The severe losses of bobwhites that are popularly attributed to red foxes do not seem to be justified here.—THOS. G. SCOTT, *Illinois Natural History Survey, Urbana, Ill. Oct. 22, 1949.*

SOME METHODS FOR TRAPPING AND MARKING RUFFED GROUSE

During the past several years the Ontario Department of Lands and Forests has sponsored a study of the life-history and ecology of the ruffed grouse (*Bonasa umbellus*) at the Wildlife Research Station on the Wilderness Area in Algonquin Park. In the course of this work, several methods for marking ruffed grouse have been tested.

In the summers of 1948 and 1949, mirror traps modified from the design suggested by Tanner and Bowers (Tanner, W. D., and G. L. Bowers, 1948. A method for trapping male ruffed grouse. Jour. Wildl. Mgt., **12**: 330–331) were used to capture male grouse. Our traps are made of half-inch mesh poultry wire fastened to a wooden frame as shown in Figure 1a. In order to prevent injury to birds in the trap, the roofs are constructed of string cloth netting. In our trap, a mouse trap has been utilized to provide a particularly sensitive trigger mechanism. A bird, entering the trap, contacts a black thread stretched across the trap and fastened to the treadle of the mouse trap as shown in Figure 1b. Increase in the tension on the thread springs the mouse trap. As the bar of the mouse trap snaps forward, it withdraws a nail which supports the door in the open position. (Fig. 1b.) As soon as the nail is released, the rubber strips fastened to the bottom of the door pull it down rapidly. The trigger thread which is fastened to the sides of the cage should be attached by small hooks so that the tension on the thread may be varied as necessary in wet weather. Light black thread has been used so that it will break readily and not entangle the bird as it struggles in the trap.

The trap has been successful in taking male grouse on the drumming logs during the drumming season, but to date no females have been taken by this means. One female was captured on the nest with one-inch gill net, which was laid around the nest while the bird was away. Later in the evening, while she sat on the nest the net was pulled up and over the bird by means of drawstrings attached to the net and extending back several yards from the nest. Since the nest was at the base of a stump it was an easy matter to arrange the net around the bird in such a way that a quick pull on the drawstrings from behind enclosed the bird between the stump and the mesh. A second female who had escaped from a similar arrangement of nets was captured late at night by two men who operated an insect net and a flashlight which was kept focused on the bird. A third female was taken on the nest in the late evening with a piece of net fastened on a more or less circular frame about two and a half feet in diameter. This was dropped over the bird while she moved about near the nest after being disturbed.

Captured birds are restrained either by hand or are placed head first, into the leg sec-

tion of a black woollen sock. Grouse are banded with regular Fish and Wildlife Service bands and one or more colored celluloid poultry bands, which are dipped in acetone to assure a firm seal between the celluloid surfaces. In addition to bands, an area on the back and tail feathers may be saturated with one of several dyes. The following saturated aqueous solutions have been tried and found

Edminster, (Edminster, F., 1938. The marking of ruffed grouse for field identification. Jour. Wildl. Mgt., **2**: 55–57) developed a method for marking grouse wherein dyed chicken feathers were fastened into the tails of the birds. We have employed a similar technique except that we have glued the shaft of the colored feather to the shaft of the grouse feather and bound it securely with

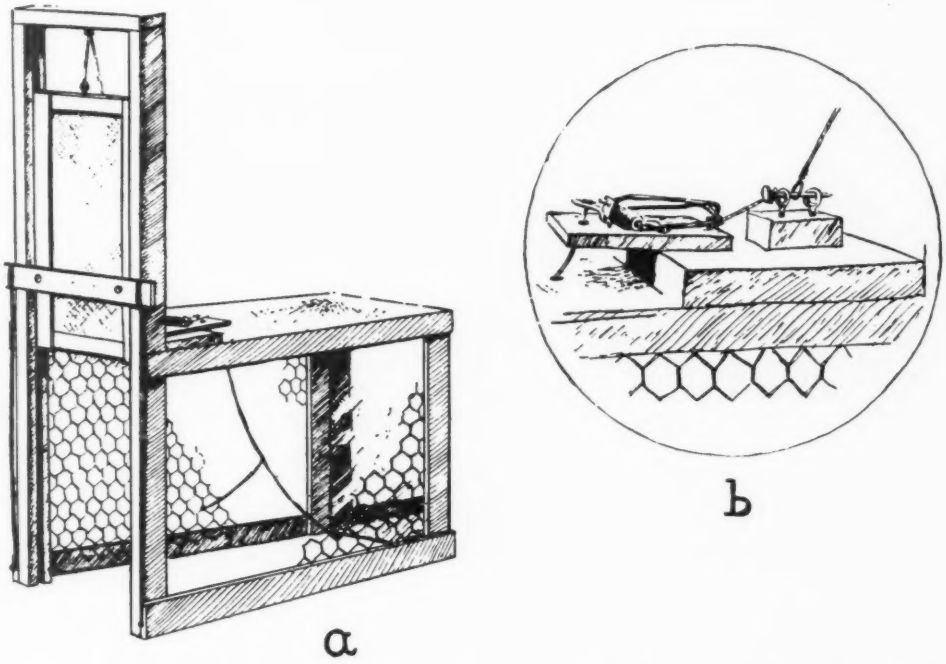

FIG. 1 (a).—Mirror trap set, showing trigger mechanism, mirror, and rubber bands fastened to bottom of door. (b) Close-up showing use of mouse trap in trigger mechanism.

to produce sufficiently bright colors to render the birds identifiable in flight: (American Society of Textile Chemists and Colorists, 1949. Technical manual and year book of the American Association of Textile Chemists and Colorists. Howe Publishing Co., N.Y.).

Auramine (Color Index No. 493)

Malachite Green Crystals (Color Index No. 495)

Victoria Blue B. Conc. (Color Index No. 559)

Resoline B. Conc. 200% (Sandoz Chemical Works, Toronto)

heavy No. 24, 6 cord, linen thread rather than with 26 gauge copper wire.

Another marking method has been successfully employed for three birds. In these cases, hens eggs were blown through an opening in one end. The empty shells were filled with printer's ink and xylene or carbon tetrachloride and the hole was sealed with cotton wadding soaked in an acetone glue. The solution should be sufficiently dilute as to be watery rather than viscous or oily. The eggs have been thrown at the grouse in such a way that they shattered on logs or adjacent

vegetation and showered the birds with ink. This technique required the observer to approach the bird to within twenty-five feet. Ideal conditions for throwing are also necessary since the vegetation or other obstructions between the bird and the observer may shatter the egg before it reaches its mark.

Birds whose feathers have been dyed are of particular value in studies of movements during the summer. Moulting birds shed characteristically colored feathers and hence leave clues to their movements. Since our intensive work is done on a 150-acre study area, it has been possible to find numerous feathers in dust baths, under roosts and elsewhere and to trace the movements of marked birds in this way.

Another technique has provided us with marked feathers, but not with visibly marked birds. It has been found that metal dusts, particularly aluminium and bronze, scattered in dust baths, will adhere to the feathers of dusting birds. Metal dust can be detected on shed feathers by passing them between the thumb and forefinger. The dust will be wiped out of the feather on to the skin of the fingers and is readily visible. It can also be seen in the feather with dissecting microscope of about seven diameters magnification.

In this way, it is possible to trace the movements of the birds using any dust bath. When birds with dyed feathers are present on an area, it is sometimes possible to find feathers showing traces of dye as well as metallic powder and hence to identify the bird utilizing a given dust bath. Occasionally, it is possible to find feathers dusted with two or more types of metallic dust, indicating that a bird has used two or more baths.

It is of interest to note that in addition to grouse, varying hare (*Lepus americanus*) and a thrush (*Hylocichla guttata*) have been captured in the mirror traps. The trigger mechanism has been used with success on wooden box traps for skunks (*Mephitis mephitis*).

ACKNOWLEDGMENTS

We are indebted to Mr. F. H. Emery of the Sandoz Chemical Works, Ltd., of Toronto, for a supply of dyes and wetting agents, and to Mr. Robert Bateman who made the diagram for Figure 1.—J. F. S. BENDELL and C. DAVID FOWLE, *Division of Research, Ontario Department of Lands & Forests, Toronto, Ontario. Feb. 28, 1950.*

Constitution and By-Laws of The Wildlife Society

CONSTITUTION

ARTICLE I—Name

The name of this Society shall be The Wildlife Society.

ARTICLE II—Objectives

The principal objectives of the Society shall be: (1) Establishment of professional solidarity and the maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; (3) publications to effect these ends; and (4) protection of the interests of its members.

ARTICLE III—Membership

Section 1. The membership of this Society shall consist of Members, Life Members, and Honorary Members.

Section 2. Membership shall be open to all persons interested in wildlife management.

Section 3. Any person may become a Member upon the recommendation of two Members and acceptance by the Secretary.

Section 4. Honorary Members shall be persons who, upon a two-thirds vote of the Council and a two-thirds vote at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management.

Section 5. All classes of Members shall be entitled to vote, to hold office to represent the Society officially, and to receive the Journal and such other publications of the Society as the Council may direct.

Section 6. Any Member may become a Life Member by paying the sum of $100.00 at one time into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

ARTICLE IV—Officers

Section 1. The officers of the Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Section 2. The officers shall be elected annually by mail ballot except as noted below. The President and Vice-President shall serve until the end of the annual meeting of the calendar year following their election and shall not succeed themselves. The Secretary shall be elected in each odd-numbered year and shall serve until the end of the annual meeting in the next odd-numbered year. Before June 1, the President shall appoint a Nominating Committee of five members. Before September 1 of that year the Nominating Committee shall submit to the Secretary two available Members as nominees for each office to be vacated. The Committee's nominations shall be published in the next October issue of the Journal of Wildlife Management or Wildlife Newsletter. Within 30 days of the date of mailing of this issue the names of additional available nominees for any office to be vacated may be submitted by any voting member in good standing and any nomination will be valid if supported by 5 per cent of the voting membership. The Secretary shall then mail to all members an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days shall be allowed for the election ballots to be returned to the Secretary. The nominee receiving the largest vote for each office shall be declared elected. In case of a tie, the decision shall be made by a majority of the Council. The out-going President shall appoint a three-member committee within thirty days after the election to audit the nomination and election ballots. The auditor's report on balloting shall be published in The Journal of Wildlife Management or Wildlife Newsletter.

Section 3. The President shall preside at meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, except the Membership Committee, including those established by the Council, and perform other duties incident to his office.

Section 4. In the absence of the President or in his inability to act, his duties shall be

assumed by the Vice-President. In the event neither one can serve, the Council shall appoint a President protempore.

Section 5. The Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings of the Society. A report covering his activities during preceding year shall be made by him to the Society at its annual meeting.

Section 6. The Treasurer shall be responsible for all funds of the Society except permanent funds held in trust and shall be bonded in suitable amounts as decided by the Council and at the Society's expense. His accounts shall be audited at the close of each year as directed by the President before presentation at the annual meeting of the Society.

Section 7. Vacancies among the officers shall be filled by vote of the Council from among the Members for the unexpired term of the office.

Section 8. The Council, by a two-third vote, may combine the offices of Secretary and Treasurer into one office entitled the Executive Secretary. The Executive Scretary shall be appointed by a two-thirds vote of the Council. The Council may pay him a salary and expenses at its discretion and within sound financial limits of the Society. The Executive Secretary shall carry out the duties and make reports as specified in Sections 5 and 6 of this Article. The combining of the offices of Secretary and Treasurer shall take place at the end of the annual meeting, of same year, and a notice of such a union shall be made to the membership at least six months prior to the change. The Council, by a two-thirds vote, may eliminate the office of Executive Secretary, if conditions warrant, and restore the separate offices of Secretary and Treasurer, and have these offices filled according to Section two of this Article. A petition, having at least 10 per cent of the signatures of Members will be sufficient to require the Council to submit to the voting membership for approval or disapproval of the appointment or discharge of an Executive Secretary.

ARTICLE V—COUNCIL

Section 1. The Society shall be governed by a Council, composed of the President, Vice-President, Secretary, Treasurer, outgoing President, and at least one representative from each of the Regions as defined in the by-laws. The Regional Representatives shall be elected annually, shall be eligible for re-election, and shall take office at the end of the annual meeting following their election.

Section 2. The Council shall appoint the Editor; shall have power to fill vacancies occurring in its numbers; shall recommend to the Society for action By-laws not inconsistent with this Constitution and shall perform such other duties as are herein prescribed. Not less than one-half of the Members of the Council shall constitute a quorum.

Section 3. If the offices of Secretary and Treasurer are combined into an office of one person, entitled Executive Secretary, an appointee, the Executive Secretary shall not vote on Council affairs.

ARTICLE VI—MEETINGS

Section 1. The Society shall hold an annual meeting and such other meetings as the Council may direct at places and dates selected by them. Due notice of such meetings shall be given by the Secretary at least thirty days in advance.

Section 2. Resolutions passed at a meeting of the Society by less than a majority of its Members shall represent the majority opinion of the meeting, but shall not be binding on the Society unless subsequently approved by the Council.

ARTICLE VII—SECTIONS

Sections of the Society may be authorized by the Council upon petition of ten or more Members. Sections may adopt necessary By-laws, providing that no part of them shall conflict with the Constitution of this Society. A report of its activities shall be presented by each section at the annual meeting of the Society.

ARTICLE VII—DUES AND FUNDS

Section 1. The annual Membership dues shall be $5.00. Subscriptions shall be $5.00 beginning with Volume twelve. No dues shall be charged Honorary Members.

Section 2. Annual dues shall be payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall receive no publications until such dues are paid.

Section 3. All monies accruing to the Society received for undesignated purposes shall constitute the Permanent Trust Fund, the proceeds from which shall be utilized to carry forward the work of the Society as directed by a three-fourths vote of the Council. In the absence of such direction, this income shall be reinvested by the Trustees.

Section 4. Bequests, grants or trusts made for the purpose of advancing the field of wildlife management and/or The Wildlife Society may be accepted by the Society, providing the Council shall have first favorably considered the objects and specifications set up by the trust. These shall be placed in the Permanent Fund.

Section 5. The Permanent Trust Fund of the Society shall be controlled in trust by a board of three Trustees with power to sell and reinvest according to their judgment. One Trustee shall be elected at each annual stated meeting for a term of three years. In case of vacancies caused by suspension, resignation or death, successors may be appointed by the Council for the remainder of the term. The Trustees shall be bonded in suitable amounts as directed by the Council and at the Society's expense.

ARTICLE IX—AMENDMENTS

The Constitution may be amended by a two-thirds vote of the Members of the Society, replying by ballot to a notice of the proposed amendment. Such notice must be submitted to all Members at least thirty days previous to the closing date for the receipt of ballots. Amendments may be referred to the Society for action either by a two-thirds vote of the Members at any stated annual meeting, or by a favorable vote of at least two-thirds of the Council.

BY-LAWS

I. ELECTION OF OFFICERS

Election of officers shall be made by mail ballot as specified by the Constitution.

II. ELECTION OF COUNCIL

Representatives to the Council shall be chosen, one from each of the following regions:

Region 1: New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, and West Virginia.

Region 2: Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

Region 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

Region 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

Region 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

Region 6: Washington, Oregon, California, Idaho, Nevada, Utah, Alaska, and Hawaii.

Region 7: Canada.

Additional Regions may be established for similar representation upon approval by the Council. Representatives to the Council shall be elected in each Region by any plan acceptable to the Council.

III. ORDER OF BUSINESS

The order of business at the annual stated meeting, unless changed by a two-thirds vote of the Members present, shall be as follows:

1. Reading and approval of the minutes of the previous meeting.
2. Report of the Secretary.
3. Report of the Treasurer.
4. Report of Regional Representatives and Sections.
5. Appointment of temporary committees.

6. Report and recommendations by the Council.
7. Action on business reported by the Council.
8. Reports of committees.
9. New and unfinished business.

IV. DELINQUENTS

A member shall be dropped from the annual list of members after becoming one year in arrears of dues. A member shall be reinstated upon payment of dues for the current year in which application is made. Any member serving in the Armed Forces of World War II may obtain back numbers of The Journal of Wildlife Management for the time he was in arrears because of the war at regular subscription prices. All other delinquents shall pay current prices for back numbers. This provision to expire December 31, 1950.

V. FISCAL YEAR

The fiscal year of the Society shall end December 31.

VI. EDITOR

The Editor shall be appointed by the Council. He shall serve for one year, or until his successor is appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council.

VII. BY-LAWS

By-laws may be adopted, amended or repealed at any annual meeting by a majority vote of the Members present.

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